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Tracing the effects of transportation and land use policies: A review of the evidence

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Tracing the effects of transportation and land use policies:
A review of the evidence

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1 Introduction

As interest in the links between land use and transportation systems has grown, planning strategies have increasingly drawn on these relationships with hopes of improving city life and promoting sustainability. These planning initiatives aim to, on the one hand, affect a shift toward more sustainable transportation through land use planning, and, on the other hand, encourage efficient land use and economic growth through strategic transport investment. Both aspects are important in the creation of strong, sustainable cities. Yet the mixed success of such land use-transport strategies highlights the importance of fully understanding their potential and demonstrated impacts on the urban system.

This paper is part of the MIT-Portugal Program's SOTUR project, which falls under a broader research initiative to develop transport innovations in Portugal. The objectives of the project are to "(1) design and simulate good practice solutions for innovative strategies on the interaction between land use and transport, specially aimed at the revitalization of urban areas; (2) improve the utilization of public transport and to increase the attractiveness and liveability of decaying urban areas; (3) enhance the understanding of agents' behaviour considering social, economic and political interests; and (4) provide recommendations for urban management through better articulation between the different decision levels."

As part of the first work package in the SOTUR project, this paper will lay the groundwork for future research by reviewing the current literature on the effects of land use-transport strategies. Focus will be on research in Europe and North America, with special attention to elements of successful policies and opportunities for urban revitalization. In particular, the paper will attempt to answer the following questions:

1. *What does the literature say about the relationship between the built environment and transportation?*
2. *What planning interventions exist that intend to leverage the land use-transport interaction?*
3. *How does current research assess the effectiveness of these policies?*
4. *What research questions remain unanswered?*

This paper is organized as follows. Section 2 discusses the theoretical basis of land use-transport planning. Section 3 reviews research on the effects of regional urban forms and individual planning interventions. Section 4 discusses issues related to implementation and policy design. Section 5 addresses the role of indicators and evaluation programs. Finally, Section 6 draws conclusions and identifies directions for further research.

2 Theoretical Foundation of Land Use-Transport Relationships

Before reviewing empirical evidence, it is useful to examine the theory behind land use-transport interactions. Conceptually, the land use-transport system consists of a complex set of interactions between forces acting within and upon the urban environment. Much

has been written on these theoretical relationships; for some reviews, see Stead and Marshall (2001), van Wee (2002), Maat (2005), and Handy (2005). The literature tends to discuss theory in terms of two complementary relationships: the impact of the built environment on travel behavior and the impact of transport on development patterns. The concept of accessibility—defined as the ability to reach desired employment, services, or activities—links these two interactions in that the accessibility of activities, as determined by the built environment, drives travel decisions while the relative accessibility of locations, as determined by the transport system, drives development decisions.

2.1 The Impact of Land Use on Travel

The theory most prevalent in land use-transport literature presumes that individuals make travel decisions primarily to minimize travel cost. This assumption implies that land use influences travel behavior in a number of ways. For one, high density, mixed-use areas are expected to involve shorter distances between homes, jobs, and services in comparison with low density, single-use development. The shorter distances between destinations would reduce the total number of miles traveled, increase the opportunities to include more destinations in one trip, and make walking or bicycling more practical and attractive. In other words, high density and mixed use would reduce vehicle miles traveled, reduce the number of trips, and encourage mode switching. Higher densities are also expected to make public transit a more viable option by increasing the potential passenger base and reducing distance from destinations to transit stops (Pushkarev & Zupan, 1977). With better public transport, supposedly, more people will switch from driving to transit. However, as this paper will show, empirical evidence validates these expectations only to a limited degree. It is clear that the prevailing theory does not tell the whole story.

Two alternative views, utility-based theory and activity-based theory, contribute to a more complete explanation. In the *utility-maximization* model, individuals make travel choices not just to minimize travel costs, but to maximize utility; that is, the benefits obtained by participating in an activity after the costs of reaching that activity are taken into account. From this perspective, higher density development may result in a person traveling shorter distances, or it may result in that person choosing a more distant, more attractive destination from which he or she will obtain more utility. According to utility theory, high-density, mixed-use development could reduce vehicle miles traveled, but it could equally well increase travelers' range of destinations with no reductions in car use (Crane, 1996; Maat et al, 2005). Alternatively, the *activity-based* approach suggests that people make travel decisions based not upon individual trips, but upon their entire pattern of daily activities. Moreover, these activity patterns are constrained by practical considerations, such as fixed work hours or family members' schedules. In addition, it has been shown that the average individual's amount of daily travel time is relatively fixed; it is unlikely, on average, that people will significantly reduce their amount of travel per day (Schafer & Victor, 2000; Redmond & Mokhtarian, 2001). When these additional considerations are taken into account, the role of land use in travel decisions becomes much more complex.

2.2 The Impact of Transport on Land Use

The opposite relationship—transportation’s impact on development patterns—has long been studied in the context of urban location theory, which was first discussed by von Thunen (1826) and further developed by Alonso (1964), Muth (1969), and Mills (1972). In this relationship, the transport system influences development patterns by determining the relative accessibility of locations; that is, the relative ease of traveling to or from a location. Transport’s impact on land use may be in terms of the location, rate, or characteristics of development. For example, the opening of a new transit station increases the ease of travel to other destinations. This increase in accessibility may make the area around the station a more desirable place in which to live, increasing residential property values and population density. Changes in the transport system may also induce aggregate shifts in travel mode choice, which can influence land use characteristics. For example, the new rail transit station may induce some drivers to switch to transit. With fewer drivers, there might be a higher demand for walkability and the resulting land use pattern may eventually have more pedestrian-friendly elements such as sidewalks.

The bidirectional relationship between transport and land use can reinforce itself in complex ways; for example, lower transport costs lead to more spread out development, which would increase distance between destinations, which would cause more people to drive. Increased car ownership may induce more road-building, which would in turn lower costs for car travelers and alter development patterns.

2.3 Economic Benefits of Transport

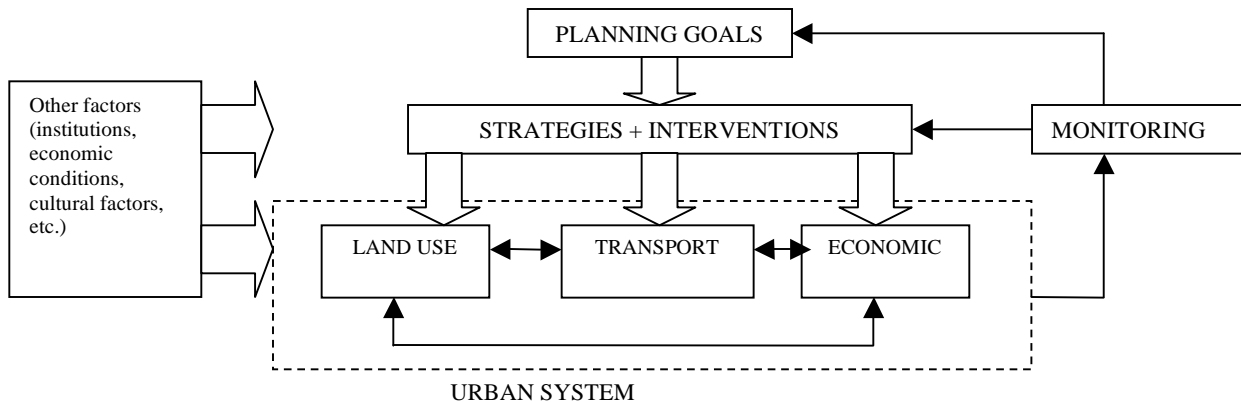
It is also widely accepted that investment in the transport system can produce societal benefits beyond those included in travel behavior changes. Economic benefits of transport investment can be either *generative* or *redistributive* (Cambridge Systematics Systematics, Inc., 1998). Generative benefits are real gains in net economic growth that result from either increased accessibility (e.g. better access to jobs allows more people to be productive in the economy) or agglomeration effects (e.g. high capacity transport systems allow clustering of industry, leading to economic spillover effects). These benefits represent economic growth in the region that would not have occurred without the particular transport investment. Redistributive benefits, on the other hand, represent localized economic growth that would have occurred anyway, but either at a different location or in a more dispersed manner. For example, the opening of a new transit stop attracts development to that location because of increased accessibility, but that development would have occurred elsewhere in the region had the stop not been built. Redistributive effects typically accelerate development in one location at the expense of other locations and therefore may be positive or negative depending on one’s perspective.

2.4 Theoretical Policy Framework

The two-way land use-transport relationship is at the core of a more extensive web of relationships surrounding the urban system (see Figure 1). In this framework, broad planning goals are translated into planning strategies and interventions, which in turn act on both land use and transportation. The land use-transport system interacts with other forces—including institutional framework, economic conditions, financial constraints, and cultural factors—that influence which policies are adopted, how they are

implemented, and how they affect the urban system. Land use and transport also interact strongly with the regional economy. Finally, feedback mechanisms like monitoring programs allow planning strategies to respond to actual urban conditions.

Figure 1. Interactions between the land use-transport system, policies, and outside factors



According to this conceptual model, land use-transport planning interventions should be able to, first, influence the location and type of development and, second, to encourage efficient travel patterns. The question is, *to what extent do these theoretical relationships hold true in reality?* The remainder of this paper attempts to answer this question.

3 Strategies and Policy Interventions

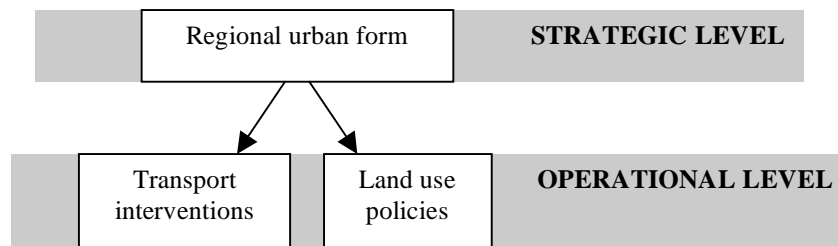
The number of planning initiatives from which to draw examples is growing. Most major cities, especially in Europe, have adopted some form of integrated land use-transport strategy with the ultimate goal of increasing sustainability, as Martens and Eijkelenbergh (2000) recognized in a survey of European cities. Almost universally, cities define sustainability in terms of three familiar components: economic, environmental, and social. Many cities' plans share other objectives as well, particularly quality of life, attractiveness, and accessibility, although the level of emphasis on each aspect differs in each context. Increasingly, cities name reduction of greenhouse gas emissions a specific objective. The proliferation of planning initiatives provides material for research, although many cities' policies are still too recent to produce conclusive long-term results.

The literature on land use-transport policies takes many different forms and uses a wide variety of methodologies. Research detailing specific strategies and interventions adopted by cities is extensive and is dominated by case studies (Martens & Eijkelenbergh, 2000; Kuzmyak et al, 2003; Bengston et al, 2004; Vieira et al, 2007). A smaller number of studies have attempted to evaluate the results of these interventions. Research that does address the efficacy of policies is usually in the form of case studies that qualitatively describe outcomes. Many other studies use simulations to describe predicted outcomes (Webster & Paulley, 1990; Wegener & Furst, 1999; Waddell et al, 2003; Spiekermann & Wegener, 2004). A limited number of studies attempt to evaluate

policy outcomes empirically using a variety of methods, including econometrics, spatial analysis, discrete choice models, economic production functions, and meta-analysis (Cervero, 1994; Cervero & Kockelman, 1997; Nelson, 1999; Williams, 1999; Cervero, 2003; Schwanen et al, 2004; Renne, 2005; Song, 2005; Debrezion et al, 2007; Shen & Zhang, 2007).

In an idealized planning process, land use and transport decisions take place at one of two levels: *strategic* or *operational* (see Figure 2). At the strategic level, cities or regions adopt an overall strategy for spatial form. For instance, a city may follow a strategy of concentrating growth in an urban core and in surrounding satellite centers connected by transit. The strategic level encompasses both land use and transport considerations. At the operational level, governments enact specific measures designed to support the ideal regional spatial form. In order to achieve a compact urban form, for example, a city may adopt zoning laws which limit growth in rural areas, or it may decide to build a new transit line. Interventions at the operational level may be categorized by those which affect land use and those which affect transport (although there is often some overlap).

Figure 2. Decisions regarding regional urban form, made at the strategic level, inform planning interventions at the operational level.



Of course, most planning contexts are far from ideal. In reality, few governments have the capacity to make or implement strategies of regional urban form. In many cases there is a serious disconnect between regional, strategic decisions and local, operational policies. Other places lack a mechanism for regional decision-making altogether. The implications of such institutional contexts will be discussed later in this paper. Even given these realities, the strategic/operational distinction is useful for examining policies. The following sections provide a summary of the research available for various planning strategies and interventions, beginning with the strategic level of regional urban form and following with policies at the operational level.

3.1 Strategic Level: Regional Urban Form

Regional urban form is often considered one of the strongest factors in influencing travel patterns. While the debate over the ideal urban form is far from settled, most cities concerned with sustainability subscribe to some variation of the “compact city,” whether it is a single, dense urban center, a strong urban core with multiple subcenters, or a network of equally-sized compact cities (Martens & Eijkelenbergh, 2000; Williams, 2000). However, some authors have questioned the actual sustainability of the compact city (Williams, 1999; Jenks, 2000; Williams, 2000).

Other studies question the assumption that regional form is always important to travel behavior. The TRANUS modeling study simulated the travel effects of various development patterns in a hypothetical British town and found that even drastically different development patterns had very little effect on overall travel, fuel consumption, or modal choice (Barra, 1989). However, in a similar study, Rickaby (1987) modeled a similar hypothetical town—but at a regional rather than town-level scale—and concluded that the location of development does significantly affect fuel consumption.

Research on the travel impacts of regional urban form relies more often on simulation studies than empirical studies; however, there are some examples of the latter. Table 1 presents a summary of the research.

Table 1. Demonstrated Impacts of Regional Urban Form

	Reference	Land Use Impacts	Travel Impacts
Compact City	Williams, 1999; Schwanen et al, 2004; Spiekermann & Wegener, 2004; Rodriguez et al, 2006	Higher density	Effect on VMT mixed, increase congestion
Monocentricity	Wegener & Furst, 1999	Usually higher density	Lower transit share, slightly lower VMT
Polycentricity	Clark & Kuijpers-Linde, 1994; Cervero & Wu, 1998; Wegener & Furst, 1999; Schwanen et al, 2004	Varies	Increase VMT, increase transit use, increase travel times
Linear City	Smith & Raemmaekers, 1998	Unknown	Possibly decrease VMT

3.1.1 *The Compact City*

While many cities adopt the compact city as an ideal, research shows that its effects on the sustainability of travel are mixed. High density urban development generally uses less land and reduces travel distances, but causes more traffic congestion (Williams, 1999; Williams, 2000). Schwanen et al. (2004) found that the Dutch compact city policy reduced driving distances and increased transit share but also increased travel times, presumably due to congestion or use of slower modes. Williams (1999) showed that intensification strategies in London have had similar outcomes. A modeling study based on Dortmund suggested that, enacted alone, a compact city policy would only slightly decrease carbon dioxide emissions from transport, although it could have a larger effect when combined with policies to increase driving costs (Spiekermann & Wegener, 2004).

Using a statistical analysis of 25 large U.S. cities, Rodriguez et al. (2006) examined the significance of containment policies (defined as an urban growth boundary, urban service area, or greenbelt) on land use and travel outcomes. The study found that the presence of an urban containment policy was associated with higher population density but, surprisingly, also more vehicle miles traveled. This unexpected outcome may be explained by the lack of coordinated regional policies, which may have allowed development to “leapfrog” outside the urban boundary, resulting in more sprawl and longer commutes. Alternatively, in the absence of complementary transport policies, containment strategies alone may have been too weak to induce change.

In sum, it appears that compact city strategies can be successful in reducing driving and associated emissions only if paired with complementary policies to improve public transport and discourage driving.

3.1.2 Monocentric vs. Polycentric Form

The ideal monocentric city consists of urban development centered around a single business district, while polycentric forms consist of a primary core surrounded by subcenters or a number of interconnected but similarly sized urban centers. Research on the sustainability of these forms is instructive but inconclusive.

In the 1970s and 80s, the Randstad region adopted a strategy of “concentrated decentralization” to focus growth in a number of peripheral urban centers while prohibiting development in rural areas. While this strategy of polycentrism was successful in directing growth to designated suburban centers, it was also blamed for the decline of inner city areas. In terms of travel impacts, a study by Schwanen et al. (2004) suggests that the results of this strategy have been mixed. While the decentralization led to greater transit use, the shift was probably at the expense of bicycle use. In an earlier study, the same authors reported that polycentrism seems to lead to greater commuting times (Schwanen et al, 2003).

Evidence from the U.S. also suggests that polycentric forms are associated with longer commutes, although it is difficult to attribute this effect directly to urban form as opposed to general regional growth. Working in the San Francisco area, Cervero and Wu (1998) found that commute times and distances increased as the region became more decentralized and polycentric. Clark and Kuijpers-Linde (1994) reported similar findings in Southern California.

It is generally acknowledged in the literature that monocentric forms are ideal for smaller cities, while larger cities should take a more polycentric form (Martens & Eijkelenbergh, 2000). However, research on travel patterns does not address this question, and in any case, it is unclear at what point a growing city should ideally transition from a monocentric to a polycentric form.

3.1.3 The Linear City

Another variation on the compact city envisions a city built around densely developed transit corridors. For example, Curitiba’s “star” pattern, combined with strict land use policies and consistent public support for transit, has resulted in significantly less car use and energy consumption compared with cities of similar size (Smith & Raemaekers, 1998). It is unclear how well the linear city model performs without strong accompanying land use and transit policies.

3.2 Operational Level: Land Use Policies

3.2.1 *Empirical Evidence of the Impact of Land Use on Travel Patterns*

The effect of land use on transportation has been researched extensively and, given the number of literature reviews covering the nature of the research, only a summary will be presented here. (For more extensive reviews see Wegener and Furst (1999), Badoe and Miller (2000), Boarnet and Crane (2001), Stead and Marshall (2001), and Handy (2005).) Most empirical evidence on the subject is mixed, but there are a few points of consensus. Most notably, the vast majority of studies find that higher density is the most important land use factor in reducing vehicle miles traveled (VMT) (Levinson & Wynne, 1963; Newman & Kenworthy, 1991; Parsons Brinckerhoff Quade & Douglas, Inc., 1996; Cervero & Kockelman, 1997; Camagni et al, 2000; Ewing & Cervero, 2001; Stead, 2001; Naess, 2006). Access to public transit is also an important factor in reducing VMT. Mixed land use appears to reduce driving, although the evidence here is not entirely conclusive (Parsons Brinckerhoff Quade & Douglas, Inc., 1996; Cervero & Kockelman, 1997; Crane & Crepeau, 1998; Boarnet & Crane, 2001). Urban design characteristics, such as enhancements to the pedestrian environment, can sometimes reduce VMT, but the impact is very small (Cervero & Kockelman, 1997; Handy & Clifton, 2001; Cervero & Duncan, 2003; Naess, 2006).

Current research on the land use-travel relationship focuses mostly on two issues: (1) the degree of causality versus correlation in the relationship and (2) the influence of attitudes, lifestyle, and socio-economic factors on travel and location decisions (Bagley & Mokhtarian, 2002; van Wee, 2002; Krizek, 2003; Handy, 2005; Levine et al, 2005; Vance & Hedel, 2007). The question of resident self-selection has received a particularly large amount of attention (Handy et al, 2005; Cervero, 2007). These studies seek to determine whether the lower levels of driving observed in transit-accessible neighborhoods are a result of those neighborhoods' urban form or a result of "transit-supportive" residents choosing to locate there.

Despite these ongoing questions regarding causality, empirical evidence of the land use-transport interaction suggests that good land use policies can, in some cases, promote sustainable travel patterns. The question is can planning interventions actually produce these results? If so, under what conditions?

3.2.2 *Land Use Planning Interventions*

The section reviews policy measures which act on the land use side of the land use-transport equation. Table 2 provides a summary of the findings.

3.2.2.1 Location Policies

Several cities employ policies that give priority to development in designated areas—usually locations that are accessible by transit and/or within walking or biking distance of employment—while discouraging growth in peripheral areas. These policies are often enforced through economic incentives, such as priority for government funding.

In perhaps the most well-known strategy of this kind, the Netherlands' "ABC policy" prioritized locations for employment growth based on access to transit. "A" locations were in the central city and received highest priority, "B" locations were typically outside the city center but had good access to public transport, and "C" locations were mostly in outlying locations with easy highway access (Schwanen et al, 2004). In spatial terms, the policy has prevented uncontrolled sprawl and has directed growth toward designated areas. However, more growth occurred at the peripheral C locations than was intended, which has contributed to decentralization of employment and population. The failure of the policy in this regard was partly due to unexpectedly high employment growth, which could not be accommodated at the highest priority locations. In addition, competition between municipalities to obtain economic growth may have driven local governments to promote development at C locations (Schwanen et al, 2004). In terms of travel patterns, the results have been mixed. The policy appears to have decreased travel distances and increased mode shares for transit, walking, and cycling; however, the effects have been small. In addition, some policy elements appear to have had unintended effects; specifically, the objective of supplying housing in the city center may have pushed employment to outlying locations, resulting in greater car use (Dieleman et al, 1999; Schwanen et al, 2004).

In Maryland, a program to establish Priority Funding Areas gave preference for state funding to designated growth areas that met certain criteria for minimum density and service infrastructure. Two empirical studies concluded that this initiative, when combined with other policies, was often associated with more concentrated growth in specified areas, higher residential density and smaller single-family residential lot sizes, although the effects were not uniform across municipalities (Song, 2005; Shen & Zhang, 2007). In some counties, inconsistent land use policies appear to have undermined the program; the policy was less successful in places that lacked complementary measures to restrain rural growth. As expected, the program was most effective in counties which had a strong tradition of managing growth (Shen & Zhang, 2007).

Renne (2005) describes early outcomes from New Jersey's Transit Village initiative, which prioritized growth in specific areas focused around transit and has seen both popular and political support. Although the full effects are not yet apparent, the report suggests that targeted towns have a greater diversity of housing types, higher transit share, and lower car ownership. Some towns display higher housing density and this density is increasing.

These cases illustrate the importance of regional coordination for location policies. The Netherlands was largely successful in coordinating between many disparate local governments to implement its ABC policy, although competition between localities undermined some of the program's ability to centralize growth. The coordination that did occur was aided by a strong tradition for spatial planning and a municipal finance structure that supports cooperation (Dieleman et al, 1999; Schwanen et al, 2004). New Jersey's initiative relied upon consistency in plans between state and local levels made possible by formal mechanisms for communication between governments. Inter-sectoral cooperation between government agencies at the state level also appears to have

contributed to the success of the program (Renne, 2005). In Maryland, the priority area program was most successful in settings with established planning traditions and where land use policies were well coordinated (Shen & Zhang, 2007).

3.2.2.2 Growth Boundaries

Some urban regions establish a boundary to contain development within a given area. The intention of a growth boundary is to increase density and preserve rural land by concentrating growth in the existing urban area.

Perhaps the most extensively studied growth boundary in the U.S., in Portland, Oregon, is widely considered a success, but it is not without negative side effects (Bengston et al, 2004; Jun, 2004). In an extensive empirical study of urban form, Song (2005) measured five dimensions of neighborhood design (street connectivity, density, land use mix, accessibility, and walkability) in several Portland neighborhoods built at various times throughout the last century. Based on the construction date of each neighborhood, the study concluded that Portland's growth boundary, when combined with other policies, was associated with increased single-family residential density and local street connectivity, but had no significant effect on the other variables. In contrast, by analyzing spatial statistics for new development, Jun (2004) concluded that Portland's boundary failed to increase density or prevent sprawl, largely because development occurred in communities which lay outside the boundary and were not covered by the same land use regulations. In support of the growth boundary's success, Nelson (1999) found that, following the implementation of state-level growth management programs which included the urban growth boundary, density in the state of Oregon fell by much less than the U.S. average. In addition, the state's growth in VMT per household slowed dramatically in comparison with other states.

Although not exactly a growth boundary, the Dutch land use policy of prohibiting all out-of-town shopping centers was largely successful in curbing sprawl and reducing car travel. It also increased the number of shopping trips made by foot and bike, although auto travel times grew longer due to increased congestion (Schwanen et al, 2004).

A series of modeling studies in Europe suggests that strong urban containment policies decrease car travel, increase transit use, and have a positive economic impact on the city centre (Wegener & Furst, 1999). The UrbanSim model of Wasatch Front, Utah predicted that an urban growth boundary would substantially decrease VMT and slightly increase transit use, but would also increase congestion (Waddell et al, 2003). However, these modeling studies do not address complicated issues involved in implementing containment policies.

Table 2: Demonstrated impacts of land use policy interventions and conditions necessary for these impacts

Intervention	Examples	Land use impacts	Travel impacts	Necessary conditions		
				Institutional/ regulatory	Economic	Local physical context
Location policies ¹	Netherlands, Maryland, New Jersey	↑ density, ↓ sprawl	↑ transit use, effect on VMT unknown	Strong regional coordination, cooperation between sectors, strong planning tradition, consistent land use policies	--***	--
Growth boundary ²	Portland, Netherlands	↑ density? [*] , ↑ sprawl due to “leapfrogging”? ^{**}	↓ VMT? [*] ↑ transit share? [*]	Strong regional coordination	--	--
Concurrency laws ³	Florida, Minneapolis	↑ density? [*] Mixed effects on sprawl	↑ VMT? [*] ↑ congestion? [*]	Strong regional coordination, consistent land use plans	Regional coordination & consistent plans more important when economic growth is strong	--
Land preservation ⁴	Maryland, Germany	↓ sprawl, ↑ density? ^{**}	unknown	Regional coordination		--
Transit-oriented development ⁵	Portland, New Jersey, San Francisco, Netherlands, Ghent, Vienna	↑ density, sometimes ↑ mixed use	↑ transit share, ↓ VMT? [*]	Strong local gov’t OR cooperation between gov’ts & sectors; public-private partnerships may be necessary. Strong regional gov’t helps	More successful when economic climate is favorable	--
Zoning ⁶	Portland, Seattle	↑ density, ↑ mixed use, ↓ sprawl	↓ VMT? ^{**}	Regional cooperation helps	--	Public acceptance, especially if higher density is the goal
Urban design codes ⁷	Florida	Improve design	Unknown, but probably small	Strong complementary land use policies needed	--	--
Pedestrian- and bike-friendly elements ⁸	Portland, Seattle, San Francisco, Maryland	↑ local connectivity, ↑ walkability, improve design	Slightly ↑ walking	Complementary land use policies are necessary	--	Positive attitudes toward walking & cycling needed for travel behavior change
Pedestrian zones ⁹	Italy, Netherlands, Ghent, Bologna, Lubeck, York	↑ walkability	↓ driving in city center, ↑ transit use? ^{**} , ↑ walking & cycling? ^{**} , ↑ congestion? [*]	Should be paired with policies to improve public transport and discourage car use	Effect of economic conditions unknown	--
Car-free neighborhoods ¹⁰	Germany, Amsterdam, Edinburgh, Vienna	↑ walkability	↓ VMT, ↑ transit use, walking & biking	Coordination between sectors	--	Good public transit & high support for car-free lifestyles
Incentives for infill/brownfield development ¹¹	England, Germany	↑ density	? ^{**}	Coordination between level of gov’t, mechanisms to overcome high risk and development costs	Favorable economic conditions help	--
Parking pricing and supply ¹²	Munster, Freiburg, Tübingen, Vienna, Seattle	N/A	↓ traffic, ↓ VMT? [*]	Should be paired with improvements in public transit to gain public support	--	--

Table notes:

* the impact is expected but evidence is conflicting

** the impact is expected but there is little or no supporting evidence

*** empty cells imply that conditions are either not applicable, or the effects are insignificant or unknown.

Sources:

¹ Schwanen et al, 2004; Dieleman et al, 1999; Song, 2005; Shen & Zhang, 2007; Renne, 2005.

² Song, 2005; Jun, 2004; Schwanen et al, 2004; Wegener & Furst, 1999; Waddell et al, 2003.

³ Song, 2005; Nelson, 1999; Downs, 2003; Porter et al, 2005.

⁴ Nelson, 1999; Shen & Zhang, 2007; Pucher, 1998.

⁵ Song, 2005; Lund et al, 2004; Cervero, 2007; Renne, 2005; Evans et al, 2007; Gout & Heilemann, 2002.

⁶ Kavage et al, 2005; Porter et al, 2005; Song, 2005

⁷ Song, 2005; Cervero & Kockelman, 1997; Cervero & Duncan, 2003.

⁸ Lund, 2003; Song, 2005; Kavage et al, 2005; Kuzmyak et al, 2003.

⁹ Topp & Pharoah, 1994; Marshall & Banister, 2000; Deneef & Schroder, 2002; Fontana, 1999; Whitehead et al, 2006.

¹⁰ Sheurer, 1999; Deneef & Schroder, 2002.

¹¹ Ganser & Williams, 2007; Sousa, 2002.

¹² Pucher, 1998; Deneef & Schroder, 2002; Kavage et al, 2005.

As a regional planning tool, urban growth boundaries rely on coordination throughout the metropolitan area and thus work well in places with strong regional institutions, but face implementation barriers where coordination between municipalities is weak. Indeed, the small number of real-world examples of growth boundaries evidences the difficulty involved in garnering support for implementation. In the worst case, growth boundaries adopted in the absence of regional cooperation can actually increase sprawl by pushing growth to even more distant outlying communities (Jun, 2004).

3.2.2.3 Concurrency Regulations/Urban Service Boundary

Cities can control where and when development occurs through decisions of where to provide infrastructure and public services. Urban service boundaries attempt to contain growth by limiting public service provision in undeveloped areas; similarly, concurrency regulations allow new development only when a minimum level of services is available in order to encourage growth only where it is most appropriate. Both strategies may result in increased density, although that is not necessarily the objective.

Some studies have evaluated the efficacy of this kind of regulation in the U.S., with mixed results. In Florida, Song (2005) reports that concurrency regulations are associated with reduced single-family residential lot size and higher density. Nelson's (1999) analysis of state-level growth management suggests that policies in Florida were effective in slowing sprawl, although not in reducing vehicle travel. In fact, the study found that VMT increased more in Florida than other comparable states, although this may be partially due to an above-average increase in statewide economic growth during the same period. Furthermore, Nelson's analysis is not entirely conclusive because it does not isolate the effects of the urban service boundary from the effects of other policies. On the other hand, Porter et al. (2005) and Downs (2003) both argue that Florida's concurrency laws have failed to slow sprawl or reduce driving, mainly because of flaws in the concurrency principle itself. Concurrency allows development only in

places where adequate infrastructure is available. However, when market demand for growth is high, or when municipalities want to attract development to increase their tax base, concurrency laws may actually incentivize road building, thereby increasing sprawl. It appears that concurrency regulations can only be an effective tool in the presence of additional land use regulations and regional cooperation.

Acting through a well-established regional council, the Minneapolis-St. Paul area implemented a regional urban service area in combination with local plans to encourage compact development. According to Porter et al. (2005), the policy has been effective in controlling where growth has occurred, but the policy was not intended to directly affect density, design, or travel patterns. Reports suggest that higher density developments are appearing, but this is more likely a result of market forces and a more recent, broader smart growth initiative (Porter et al, 2005).

As with other regional planning interventions, it is clear that concurrency laws and urban service boundaries depend on strong regional coordination. For example, Minneapolis-St. Paul's established metropolitan council made it possible to implement an urban service area agreement. The region is also aided by a revenue-sharing scheme that promotes cooperation rather than competition between local governments (Porter et al, 2005). In Florida, conversely, lack of agreement between municipalities and between local, state and regional plans exacerbated weaknesses in the concurrency regulations.

3.2.2.4 Land Preservation

Land preservation policies are primarily intended to preserve valuable farmland and open space, but they may also increase density by concentrating growth. For example, in Maryland, a program to set aside agricultural land through the transfer of development rights was generally successful in preserving land, although it is unclear how it affected density (Nelson, 1999; Shen & Zhang, 2007). Land use regulations in Germany to preserve agricultural and forested areas have been credited with concentrating growth and conserving open space (Pucher, 1998).

3.2.2.5 Transit Oriented Development

Although transit oriented development (TOD) refers to a general approach to development rather than a single policy measure, strategies to promote TOD usually include certain elements, especially zoning regulations, design codes, and priority location policies. The objective is primarily to improve accessibility by locating housing and employment near transit stations, and secondarily to increase density, achieve mixed land uses, and improve walkability. The term TOD is more commonly used in North American cities, where the political environment encourages explicit terminology, than in European cities, where transit traditionally enjoys more support—but the elements of TOD are essentially the same in both places. Much has been written about how to create transit oriented development (Cervero et al, 2002) and although some research has attempted to evaluate the impacts on land use and travel, the results are not yet conclusive (Lund et al, 2004; Renne, 2005; Evans et al, 2007).

In the United States, the concept of transit oriented development is gaining popularity and appears to be seeing some success. Renne (2005) evaluated effects of policies across the U.S. and found that TOD neighborhoods generally exhibit greater transit use and substantially lower car ownership. Several studies in the San Francisco area concluded that TOD increases transit share (Lund et al, 2004; Cervero, 2007). The increases are partly due to resident self-selection: TODs tend to attract residents who are more inclined than the average citizen to use transit; thus, at least for these residents, urban form does not actually *induce* behavior change, but merely *permits* it. Still, as the authors emphasize, the phenomenon of resident self-selection does not negate the importance of building TOD. Some other examples do not specifically use the TOD label, but Portland has successfully employed zoning regulations to increase density near transit stops while Maryland has done the same using economic incentives (Song, 2005).

In Europe, where more development has historically been focused around public transport, the benefits of such development are less often debated and research tends not to focus directly on TOD. However, a number of case studies illustrate how cities have centered development around transit—for example in Ghent, Vienna, and Amsterdam—even when the term TOD is not used (Gout & Heilemann, 2002).

The instances in which TOD has been successful point to the importance of strong local government and inter-agency partnerships in directing such interventions. Implementing TOD can be fairly straightforward when local governments are strong—for example, the city of Munster simply creates transit-oriented nodes by purchasing and developing land itself—but more often this kind of development requires a complex arrangement of partnerships and collaboration between various government entities and private developers (Cervero et al, 2002). In the U.S., state-level policies which support TOD are a critical factor. For example, in New Jersey, a mechanism to formalize communication between state and local government was key to the successful implementation of TOD policies (Renne, 2005). TOD also relies in part upon favorable economic conditions that support new development.

3.2.2.6 Zoning

Zoning regulations can be used to create a mix of uses and enforce higher density. In Europe, cities have relatively strong and effective regulation authority, so the success of zoning laws has not been a major topic of research.

In the U.S., where land use controls are weaker and the existence of zoning does not necessarily guarantee the intended results, a few studies have attempted to specifically evaluate the success of zoning regulations. Kavage et al. (2005) surveyed transit-efficient development regulations in the Seattle area and found that most municipalities had successfully adopted some form of zoning to encourage compact development, especially near transit stops. The study concluded that the regulations were successful in increasing density and mixed use on the project scale. Porter and colleagues (2005) concur that zoning measures in the Seattle area appear to have increased residential density, increased infill development, and preserved farmland. The authors suggest that these changes may be responsible for the fact that Seattle's per capita VMT has slowed in

comparison with other cities. In Portland, overlay zones near transit stops that enforce minimum density requirements appear to have been successful in that intention; density of single-family housing in these neighborhoods has increased (Song, 2005).

Zoning laws are made at the local level and are therefore possible to implement and enforce without cooperation at the regional level. However, as a strategy to increase density and control growth, zoning is more effective when local plans are consistent with one another. Public perception is also important; in many areas the greatest obstacle to higher-density zoning is lack of public acceptance by those who oppose urban intensification within their neighborhoods (Gordon & Richardson, 1997; Jenks, 2000).

3.2.2.7 Urban Design Codes/Building Codes

Design regulations can be used to enhance the pedestrian environment through micro-scale design factors such as hidden parking lots and attractive building fronts. Design codes are effective in aesthetic terms, as they have a direct effect on design factors. However, empirical research suggests that design factors have very small, if any, impact on travel choices, although design is still important for other quality of life factors (Cervero & Kockelman, 1997; Cervero & Duncan, 2003).

3.2.2.8 Pedestrian and Bike-Friendly Elements

Many cities adopt policies to improve the environment for walking and cycling in order to increase the share of these modes. These measures, which are essentially targeted zoning regulations and design codes, include regulations for mixed use, requirements for street layout, and aesthetic guidelines. Song (2005) found that Portland's design guidelines for aesthetics and walkability (along with other policies) slightly increased street and sidewalk connectivity *within* neighborhoods, but did not affect pedestrian access to commercial destinations. Lund (2003) studied pedestrian behavior in certain Portland neighborhoods regarded as walkable and found that access to retail and parks was associated with a higher number of walking trips; however, residents' attitudes toward walking was a more significant factor. A case study of two neighborhoods in San Francisco concluded that pedestrian-oriented design increases the share of walking as an access mode for transit (Kuzmyak et al, 2003). Kavage et al.'s (2005) review of Seattle area policies found that zoning and design regulations intended to improve the pedestrian environment were relatively widespread and, further, that pedestrian-friendly elements were present in more than half of new developments, but that these improvements were not necessarily a result of the regulations.

Since pedestrian and bicycle factors usually work at the local or neighborhood level, their implementation is less dependent on regional cooperation. However, measures to improve the walking and cycling environment are more effective if policies are consistent among adjacent municipalities and throughout the metropolitan region.

3.2.2.9 Pedestrian Zones/Car-Restricted Areas

European cities in particular have had extensive experience with pedestrianization of city centers, the impacts of which have been documented in several studies. Topp and Pharoah (1994) present case studies of efforts to restrict cars from the city centers of

Bologna, Aachen, Lubeck, and York. The report suggests that these pedestrianization schemes were successful in significantly reducing car traffic in the inner city while retaining strong public support. Bologna appears to have avoided major traffic increases in areas outside the pedestrian zone, in large part because the measure was accompanied by improvements in public transport. The report also suggests that Lubeck's initiative, which applied only to weekends, was responsible for 12% of former drivers switching to walking, cycling, and public transit. Like Bologna, Lubeck attempted to improve public transport options on the car-free days. Although no data are available on the economic impacts, retailers in Lubeck who originally opposed the plan later advertised the attractive shopping environment it created.

Fontana (1999) reviewed the traffic restrictions enforced in many Italian city centers and found that these regulations greatly reduced traffic in the restricted area, but led to increased congestion elsewhere, increased motorcycle use, and public criticism. To explain these criticisms, Fontana suggests that the chosen car-free areas were too large and regulations were implemented too quickly. In the Dutch town of Enschede, restricted car access to the central shopping district resulted in modest reductions the share of car trips to the city center (Marshall & Banister, 2000). In Manchester, results of an economic modeling study suggest that pedestrianization schemes can attract business activity to city centers and may be useful in urban revitalization; however, the study lacked details regarding specific conditions or how revitalization might be accomplished (Whitehead et al, 2006).

The above cases show that pedestrian zones can be effective in reducing driving and enhancing the urban environment, but they must be paired with measures to upgrade public transport and discourage car use. Without complementary policies, traffic may be diverted to outside the central area, resulting in congestion and reduced activity in the city center (Topp & Pharoah, 1994). It is also unclear how economic conditions impact the success of pedestrianization plans. On one hand, a decrease in vehicle accessibility may harm a struggling city center, but, on the other hand, pedestrianization may help to revive a declining area. In either case, it is likely that well coordinated transport and economic policies are needed if a car-free area is to thrive.

3.2.2.10 Car-Free Neighborhoods

Entire neighborhoods designed specifically to support car-free or car-reduced lifestyles have been growing more popular, particularly in northern Europe. Car-free neighborhoods obviously involve self-selection since only the car-conscious would elect to live there. Not surprisingly, these developments exhibit a much more sustainable mobility profile than the average neighborhood. Sheurer (1999) measured mobility characteristics of car-restricted neighborhoods in Amsterdam, Edinburgh, Hamburg, Vienna, and Freiburg and found that the proportion of car trips (mainly with shared vehicles) in most neighborhoods is under 10%. Other cities with car-free neighborhoods include Cologne, Munster, and Tübingen (Deneef & Schroder, 2002).

Car-free neighborhoods clearly have limited applicability: their success requires good access by other transport modes and a willingness to live an auto-free lifestyle. However,

the growth of car-restricted developments in Europe suggests that there is a demand for this kind of development (Deneef & Schroder, 2002).

3.2.2.11 Incentives for Infill and Brownfield Development

Policies to encourage infill and brownfield development are intended to increase density within the urban area and slow sprawl in outlying areas. As one study estimates, brownfield redevelopment can result in significant transportation cost savings for the public (Sousa, 2002). Brownfield legislation in some countries (including Portugal, Denmark, Austria, Bulgaria, Finland, and Sweden) focuses narrowly on cleaning contaminated sites. In others, legislation explicitly recognizes how reuse of urban land, contaminated or not, contributes to compact city form (CABERNET, 2004). England and Germany in particular have adopted quantitative targets for infill development. Reports show that policies in England have been successful in approaching the target, where 66% of new homes have been built on previously developed land and the site density of newly constructed developments has continued to increase (Ganser & Williams, 2007). However, the interventions may have had unintended consequences, such as the displacement of land uses other than housing. Germany's stated target is to reduce the rate of greenfield development, but it is too early to judge the initiative's effects.

Success of brownfield and infill development initiatives is dependent on several factors. First, incentives must be substantial enough to outweigh the costly and time-consuming approval procedures and environmental clean-up that are inevitably needed. As brownfield development involves an unusually high amount of risk, mechanisms must be in place to mitigate or compensate for that risk. Additionally, since inconsistencies between national brownfield policy and local plans can create a barrier to redevelopment of those sites, inter-governmental cooperation is important. Like most development, the redevelopment of brownfields is more likely during periods of economic growth (McCarthy, 2002; Ganser & Williams, 2007).

3.2.2.12 Parking Fees and Supply Restrictions

The aim of parking management strategies is to discourage driving by increasing parking costs and/or limiting availability of parking spaces. Cities sometimes have direct control over parking (as with street parking spaces), or sometimes parking is controlled through zoning mechanisms. In conjunction with pedestrianization of the city centre, Tübingen successfully used strategic parking supply management to reduce traffic in the city centre by 11%. Parking time limits in Vienna reduced parking space utilization rates, time spent searching for parking, and illegal parking (Deneef & Schroder, 2002). Kavage et al. (2005) found that project-scale regulations to manage parking supply were relatively uncommon in the Seattle area and, furthermore, regulations that did exist had little effect on the supply of parking.

Since limitations on parking are often politically unpopular, they are more successful when combined with other measures, like improvements in public transportation.

3.3 Operational Level: Transport Interventions

Changes in the transport system can impact travel patterns, urban form, and economic conditions. It is well known that transport improvements provide societal benefits through changes in travel behavior (e.g. travel time savings, reduced VMT). Not surprisingly, research suggests that, taken alone, transport system policy measures are much more effective in influencing travel behavior than are land use planning measures (Lautso, 2004; Clifford et al, 2005). The ability of transportation to influence urban form is also well established, at least in theory. It is also widely believed that transportation interventions, particularly investments, produce additional economic benefits beyond those captured by travel behavior. However, a review of the research is necessary to understand how transport interventions actually influence development.

The following section reviews research of the impacts of transport-side interventions on land use patterns and economic growth. Emphasis is on empirical studies, but modeling studies are included where empirical research is not available. In the following analysis, the term “intervention” refers to either investment in the transport system or policies which affect transport. The research findings are summarized in Table 3.

3.3.1 *Impacts of Transport Investment*

While modeling studies largely support the hypothesis that investment in transport accelerates development and generates economic benefits, empirical analyses reveal that, in practice, the outcomes are complicated by many external factors and benefits are usually limited (Giuliano, 2004; Clifford et al, 2005). In particular, the research identifies three important points: (1) improvements in accessibility demonstrate diminishing returns, (2) economic benefits are often redistributive rather than generative, and (3) impacts depend heavily on external factors.

In general, studies have found that transportation improvements exhibit diminishing returns in terms of economic benefits. In other words, areas with poor transport infrastructure will benefit greatly from new investment, but as the level of accessibility increases, the marginal benefits resulting from additional infrastructure decrease. Additional facilities in areas that are already well served by transport—as is the case in most developed countries—are unlikely to have a large effect (Parsons Brinckerhoff Quade & Douglas, Inc., 1996; Cervero, 1998; Pickrell, 1999; Wegener & Furst, 1999). These findings question the societal economic benefits of transport investments, however; new facilities can still provide other benefits such as modal shifts.

The research indicates that many economic benefits from transport investments are redistributive; while they can promote development in a certain location, it is often at the expense of development in other locations. For example, using long-term economic data from California, Boarnet (1998) confirmed that infrastructure investments in one area led to reduced economic activity in neighboring areas. From a local point of view, this may be precisely the goal; however, as Handy (2005) points out, it is more often outlying suburbs that benefit at the expense of inner cities.

Empirical studies of transport investment have produced conflicting results in large part because the effects are always context-sensitive and depend heavily on local conditions, especially complementary land use and economic policies. Banister and Berechman (2001) identified three conditions needed for transport investment to spur economic growth: a buoyant economic environment, supportive political conditions, and sound decisions relating to the nature of the investment itself (such as the timing of the investment and physical location within the network.) Without all three of these, investments will not have a significant impact on the regional economy.

It bears noting that the objectives of transport investments vary. With respect to land use and development, the goal of many projects is net economic growth, but in other circumstances the concern may be controlling sprawl or redirecting existing growth. Thus this paper does not attempt to evaluate the “success” of investment projects, but to objectively examine what is known about effects on land use and the regional economy.

3.3.1.1 Transport Investment and Urban Revitalization

While the ability of transport investments to accelerate development is well established, few studies focus specifically on how to leverage the transport-urban form interaction for the purpose of inner city revitalization. Observation suggests that, even though most of this development is likely to be redistributive in character rather than generative, it may be a useful strategy if the goal is to revitalize a specific area (Cambridge Systematics Systematics, Inc., 1998). However, the dual phenomena of suburbanization and central city decline have shown that, just as highways and transit lines can bring economic activity to an area, they can also allow activity to move away from it. As the following sections will show, transport investment has in some cases acted as a catalyst for redevelopment, while in other cases it has failed. It is difficult to separate the impacts of transportation projects from other local processes and although the following review leads to some conclusions, more focused studies are needed to better understand the revitalization prospects of transport investment.

3.3.1.2 New Networks vs. Extensions vs. Improvements

The effects of infrastructure investment depend on whether the construction constitutes an entirely new network, an additional link in an existing network (e.g. a new road), or a capacity expansion or improvement of an existing segment (e.g. a road widening). As Boarnet (1997) emphasizes, as a transport network grows, each additional link increases the usefulness of the entire network. But further improvements exhibit diminishing returns and as the network nears completion, the incremental benefits of each additional link decrease. Thus we would expect newly constructed networks to have greater impact than extensions to existing networks. By the same reasoning, expansion and improvements to existing facilities are expected to have relatively small effects on land use and development.

Table 3. Demonstrated impacts of transport interventions and role of external factors

Intervention	Necessary conditions/external factors				
	Land use impacts	Economic impacts	Institutional/ regulatory	Economic	Local physical context
Highway investment ¹	↑ development around corridors, More dispersed urban form	↑ property values, long term regional benefits, localized growth. Impacts small when accessibility is already high	Coordination w/ land use policies needed to control impacts	Favorable economic climate needed for economic benefits	Available land needed for urban development/redevelopment
Highway expansion & improvement ²	↑ development in corridor	Possible economic growth, but economic conditions are usually good anyway	Coordination w/ land use policies needed to control impacts; growth controls may be necessary	--***	--
Rail transit investment ³	↑ development near stations in some cases	↑ property values near stations, when economic growth is strong	Supportive land use policies needed to promote development; development incentives may be necessary	Favorable economic climate needed for economic benefits	Available land needed for urban development/redevelopment
BRT investment ⁴	↑ development near stations in some cases	↑ property values; effects slightly less than for rail transit	Supportive land use policies needed to promote development	Favorable economic climate needed for economic benefits	Available land needed for urban development/redevelopment
Pedestrian and bike infrastructure ⁵	More compact development?***	Regional economic growth?***	Strong land use policies probably needed for change in development pattern - infrastructure probably a weak supporting factor	--	Impacts greater in high density areas
Road/ Congestion pricing ⁶	Effects depend on policy details	↓ local property values?* Mixed effects on retail Long term effects unknown	Should be paired with complementary land use policies and transit improvements; regional coordination needed prevent shifts in activity	More feasible in favorable economic climate	Only feasible where congestion is a serious problem and transit and non-motorized alternatives are strong
Transit fare ⁷	Decentralization of housing?***	Economic benefits?***	Coordination with land use and road policies needed to achieve most objectives	--	--
Car sharing ⁸	↑ density?*** ↓ parking space	Effects unknown	Strong land use policies needed for changes in development pattern; more effective when paired with transit improvements	--	Only feasible where transit and non-motorized alternatives are strong; more feasible in population-dense areas
Bike sharing ⁹	↑ density?***	Economic benefits?*** Central city revitalization?***	Strong land use policies needed for changes in development pattern; more effective when paired with bicycle infrastructure & transit improvements	Favorable economic climate probably needed if used for urban revitalization	Area must be bicycle-friendly

Table notes:

*the impact is expected but evidence is conflicting

**the impact is expected but there is little or no supporting evidence

*** empty cells imply that conditions are either not applicable, or the effects are insignificant or unknown.

Sources:

¹ Voith, 1993; Boarnet & Chalermpong, 2002; Harder & Miller, 2000; Payne-Maxie, 1980; Bhatta & Drennan, 2003.

² Hansen et al, 1998; Ten Siethoff & Kockelman, 2002; Cervero, 2003; Sanchez, 2004.

³ Dewees, 1976; Bajic, 1983; Damm et al, 1980; Grass, 1992; Cervero & Landis, 1997; Gatzlaff & Smith, 1993; Bowes & Ihlandfeldt, 2001.

⁴ Levinson et al, 2003; Rodriguez & Targa, 2004.

⁵ Litman, 2003; Krizek, 2004.

⁶ Webster & Paulley, 1990; Prud'homme & Bocarejo, 2005; Zhang & Shing, 2006; Quddus et al, 2005; Transport for London, 2007.

⁷ Wegener & Furst, 1999.

⁸ Millard-Ball et al, 2005; Lamrani, 2004.

⁹ DiDonato et al, 2002; DeMaio & Gifford, 2004.

3.3.1.3 New Highways

The impacts of highways have been relatively thoroughly studied, especially in the U.S. For summaries of the research, this paper refers to Bhatta and Drennan (2003) and Giuliano (2004). The fundamental conclusions echo the findings about infrastructure investment in general: highway investments increase accessibility, with the greatest benefits at the site of investment. The benefit of increased accessibility is reflected in higher property values. For example, Voith (1993) found that highway access in Philadelphia was positively associated with residential property values. In studying the impact of new toll roads in Orange County, California, Boarnet and Chalermpong (2002) concluded that the new roads did increase accessibility, which was reflected in higher home prices. On the other hand, Harder and Miller (2000) found that in Toronto proximity to a highway was associated with *lower* home values. A widely-cited analysis of the impacts of urban beltways in the U.S. found that newly constructed beltways had no significant impact on economic growth, but did influence development patterns. In particular, multi-family residential and office space tended to be located near the new corridor (Payne-Maxie Consultants Consultants, 1980). These mixed results point to the importance of local context, especially regional population and employment growth, and availability of land for development.

There is ample evidence that, in the long-term, highway infrastructure can generally result in regional economic benefits. In a review of forty empirical studies, Bhatta and Drennan (2003) concluded that highway investment is positively associated with long-term economic production. However, the authors caution that growth depends heavily on local context. Furthermore, more recent highway investments, which occur mainly where road networks are already extensive have had less significant impacts on economic development (Giuliano, 2004).

3.3.1.4 Highway Expansions and Improvements

Measuring the impact of road expansions and improvements is more difficult and fewer studies address this topic. Hansen et al. (1998) found that capacity increases in California highways led to higher rates of development, especially for single-family residential and commercial uses. Working in Texas, California, and Oregon, Ten Siethoff and Kockelman (2002), Cervero (2003),

and Sanchez (2004) all confirmed that highway expansions led to higher levels of new development. However, it is important to note that all of these studies were conducted in regions during periods of overall economic growth—indeed, highway expansions normally occur in growing areas where increasing traffic necessitates extra capacity. These results do not prove that highway expansions always lead to more development. In fact, the objective of expansions is usually not to promote development but to relieve traffic congestion; in this case additional development may actually be considered a negative outcome if it is in the form of sprawl.

3.3.1.5 Rail Transit

Research on the impacts of rail transit investment is broad and, given the availability of literature reviews on this topic, this paper will not give an exhaustive account. (For more comprehensive reviews, see Banister and Berechman (2000) and RICS (2002).) However, a few studies can serve as examples. In Toronto and Washington, D.C., rail transit appears to have influenced development much as expected; studies have shown that proximity to stations is associated with higher property values (Deweese, 1976; Bajic, 1983; Grass, 1992). In Washington, this was true both before the system opened, as investors anticipated the effects of the system, as well as several years later (Damm et al, 1980).

In a study of the San Francisco Bay Area's regional rail system, Cervero and Landis (1997) found that the system's development impacts varied widely depending on local conditions. Significant growth was found in downtown San Francisco and in other communities that had favorable development policies, while in other cities restrictive policies prevented growth. In Oakland and other areas where development policies were supportive but economic conditions were weak, the rail system appears to have little impact.

Although few studies have looked at the real estate effects of rail investment specifically in transit-oriented developments, there is some evidence that land values in TODs are higher than in similarly-situated traditionally-designed neighborhoods (Cervero et al, 2004). As one might expect, the synergy of higher density, transit access, mixed uses, and walkability in TODs appears to translate into higher property values. Initial evidence suggests that property values are even higher when TOD projects are developed jointly by public and private entities, with physical integration between transit facilities and real estate development. Indeed, a study of joint development projects in Washington, D.C. and Atlanta found that these projects were associated with higher rents and lower vacancy rates compared to properties with equal access to transit stations (Cervero, 1994).

Not all rail transit investment is associated with strong performance in the real estate market, however. According to Gatzlaff and Smith (1993), Miami's rail system has had almost no effect on property values or development, a finding consistent with the system's low levels of ridership. The project's failure may be partly *because* the system was intended as an instrument for economic development. Hoping to revitalize struggling neighborhoods, planners located many of the links in areas of low economic growth, away from the established economic corridors which would generate riders (Giuliano, 2004).

In a meta-analysis of 53 rail transit impact studies, Debrezion and colleagues (2007) attempted to explain the variation in observed effects of transit on land values. The analysis found that

commuter rail stations have a larger positive impact on property values than light or heavy rail transit. Within close proximity to stations, rail lines have a larger impact on commercial property values than on residential values, but the effect is reversed as distance from the station increases. The analysis also confirmed that property value impacts are diminished in areas that have nearby highway access. In these cases, accessibility provided by the highway is already good, so the marginal increase in accessibility from the rail system is small.

There is evidence that effects of rail stations can be negative as well as positive. In a study of property values in Atlanta, Bowes and Ihanfeldt (2001) found that, in addition to the positive effects discussed above, rail stations produced negative externalities in the form of pollution, noise, and unsightliness, and were associated with an increase in crime. The negative impacts were especially pronounced in low-income neighborhoods.

In reviewing impact studies in North America, Giuliano (2004) concluded that rail transit investment alone is not sufficient for economic growth and benefits depend on supportive land use policies and good economic conditions. In addition, most impacts of new rail systems are small because they usually operate in areas already well served by buses and therefore have marginal effects on accessibility.

3.3.1.6 Bus Rapid Transit

Most studies suggest that the economic and land use impacts of bus rapid transit (BRT) are similar to those of traditional rail transit, although the research is not entirely conclusive, in large part because most BRT systems are relatively new and only a few long-term impact studies are available. However, case studies of 26 systems around the world show that BRT can increase property values and spur development with effects similar to those associated with rail transit (Levinson et al, 2003). In Bogota, empirical evidence shows that property values are higher near the city's BRT stations (Rodriguez & Targa, 2004). Conversely, empirical analyses of four BRT systems concluded that their effect on property values is significantly lower than that of rail transit (Debrezion et al, 2007).

3.3.1.7 Bicycle and Pedestrian Infrastructure

While research has speculated on economic and land use impacts of infrastructure investment for non-motorized modes, there are few rigorous studies of such impacts. Most research on bicycle facilities focuses on recreational rather than commuting uses, but in one study Krizek (2004) proposes research methods for analyzing impacts. Similarly, Litman (2003) presents a framework for analyzing the benefits of walkability that may be used in future research.

Since research on observed impacts is scarce, it is worth discussing the predicted effects of bicycle and pedestrian infrastructure. One hypothesis is that the provision of pedestrian infrastructure may support more compact, efficient land use patterns. There is evidence that access to pedestrian and bicycle infrastructure increases travel by those modes, although it is unclear how much of the increase is at the expense of automobile travel (ADONIS, 1998; Pucher, 1998; Marshall, 2004). If the result is indeed to reduce car travel, then the demand for a walkable or bikeable environment may support more compact development patterns; however, this factor is likely to be less important than land use policies in influencing development.

Litman (2003) suggests that, in addition to direct user benefits, pedestrian facilities may contribute to economic development by creating attractive shopping and tourist environments.

3.3.2 Road and Congestion Pricing

The research is clear that road or congestion pricing is a very effective way of influencing travel behavior, but the impacts on land use patterns and local economy are less apparent (Webster & Paulley, 1990; Spiekermann & Wegener, 2004; May et al, 2005). Since real-world experience with road pricing is limited to a few cities, most studies are based on theory or simulations. Theoretical investigations suggest that the long-term economic effects of congestion charging on most businesses are likely to be small but positive, although some types of businesses would be adversely affected (Whitehead, 2005). An earlier modeling study predicted that increased travel cost would have only a small effect on overall population movement (Webster & Paulley, 1990).

Most of the available empirical evidence comes from the London congestion charging scheme, and this evidence is mixed. Early studies suggest that the policy has slowed the rise of residential and commercial property values inside the charging zone, while property values outside the zone continue to increase (Zhang & Shing, 2006). Studies also show that the charge has had little impact on retail sales or the Central London economy in general (Quddus et al, 2005; Transport for London for London, 2007). Some research suggests that economic costs outweigh the benefits, while other studies argue the opposite (Prud'homme & Bocarejo, 2005; Transport for London for London, 2007).

While effective, road pricing is politically unpopular in most places and pricing initiatives will only be feasible in cities with heavy traffic congestion and when paired with measures to improve alternative modes (Henry, 2004). Santos (2005) points out that the political and technical success of congestion pricing in London, as in Singapore, is attributable to the accompanying set of policies to increase capacity of public transit.

3.3.3 Transit Fares

The literature on pricing of public transport is extensive and mostly outside the scope of this paper. Empirical and modeling studies generally show an inverse relationship between fare and transit use, but only up to a point; many drivers will not switch modes even if transit is free. Modeling studies suggest that dramatically reduced transit fares may provide economic benefits to the central city, but may also lead to more decentralization of housing (Wegener & Furst, 1999).

3.3.4 Car Sharing

Car sharing programs are expanding worldwide and this growth in popularity is expected to continue (Shaheen & Cohen, 2007). Research on the effects of car sharing is largely limited to changes in travel behavior; the effects on land use patterns are still too small to be easily measured. For example, Litman (2000) quantified the user benefits resulting from car sharing, but left broader economic benefits to speculation.

Future research may shed more light on the land use effects of car sharing. Evidence suggests that car sharing programs reduce vehicles miles traveled by users. That is, it appears that although car sharing allows previously car-free people to drive more, most sharers are former

auto-owners and drive *less* after joining a program (Cervero & Tsai, 2004; Lamrani, 2004; Lane, 2005). If car sharing significantly reduces VMT and car ownership, it could support more compact land use patterns. In particular, the growth of car sharing should reduce the need for parking, freeing land for other uses (Millard-Ball et al, 2005).

In terms of implementation, car sharing has limited applicability—it is not common outside of dense urban areas that have high walkability and good access to public transit. Using case studies, Millard-Ball et al. (2005) identify conditions necessary for successful car sharing programs, describe ways to implement programs through partnerships, and discuss how to overcome barriers to implementation. While most car sharing programs are operated privately, governments can play a role in supporting their growth (Enoch & Taylor, 2006).

3.3.5 Bike Sharing

Community bike sharing programs first appeared in the late 1960s and have since spread to many cities in Europe and Asia. While several case study reviews are available, few systematic studies have been conducted on the success of these programs (Matsuura). However, one analysis of a pilot program suggests that initial demand stems mainly from recreational use (Noland & Ishaque, 2006). A case study of Copenhagen's City Bike program suggests that the impact of bike sharing programs on mode share or VMT is small, but programs could potentially boost a city's image and help rejuvenate central city areas (DiDonato et al, 2002). DeMaio and Gifford (2004) provide an overview of existing programs and discuss conditions for successful bike sharing programs, but do not attempt to quantify findings.

4 Implementation Issues and Institutional Structures

Implementation is a critical aspect in the success of planning interventions; even if land use-transport policies are theoretically effective, they will be successful only if they are executed correctly. As the above review has shown, institutional structure is one of the most important factors in determining *if* and *how* plans are implemented. There is fairly extensive literature focused on implementation issues related to land use-transport policies and more specifically on the organizational aspects of land use-transport planning.

4.1 Barriers to Implementation

A number of authors, drawing from case studies in Europe and North America, identify barriers specific to implementation of land use and transport policies and provide guidance on how to overcome these barriers. May et al. (2006) group barriers into five general categories:

1. Legal (lack of legal authority, inadequate legislation)
2. Institutional (conflicts between or within organizations, incompetency, inefficient management)
3. Financial (availability of funding)
4. Political and cultural (lack of public acceptance or awareness, problems with professional traditions)
5. Practical and technological (physical barriers, unavailable technology)

Other research identifies very similar sets of barriers (Dieleman et al, 1999; Williams, 1999; Bengston et al, 2004; Filion & McSpurren, 2007).

Gaffron (2002) makes a distinction between embedded and contingent barriers. Embedded barriers are inherent conditions external to the policy realm, such as local topography or economic structures. Embedded barriers are therefore more difficult to overcome than contingent barriers, which are constructed by human process—for example, organizational structures or fiscal policy.

The EU's TRANSPLUS project (TRANSPLUS, 2002) analyzed case studies of several transport-land use planning problems in Europe. The report gave examples of general strategies for overcoming contingent barriers, as summarized in Box 1.

Box 1. Strategies for overcoming implementation barriers and examples from practice

(TRANSPLUS, 2002)

1. Integrated strategic concepts

A regional planning initiative in Ghent used a comprehensive approach from the earliest stages of strategy development which included planning for disparate but interlinked issues such as land ownership, road infrastructure, and housing development.

2. Integrated sectoral policy

Bristol has been successful in integrating land use and transport policies due to an organizational structure that combines transport and land use planning functions within a single organization at each level of government—e.g., at the local level there is the Department of Transport, Environment and Leisure at the county level, the Joint Strategic Planning and Transport Committee, and so on.

3. Interdisciplinary collaboration

In creating and implementing a local transport plan, Merseyside was faced with a proliferation of agencies that each had authority over some aspect of the plan. The solution was to establish a joint working group to coordinate between them.

4. Regional cooperation

Amsterdam has been able to resolve conflicts between the regional planning authority and neighboring towns through a strategy of direct collaboration and recognition of mutual interests.

5. Step-by-step implementation process

In the 1970s, Rome began an initiative to reorient its historic center around pedestrians instead of cars. By taking gradual, incremental measures to restrict car traffic and reconfigure streets, the city avoided the large traffic problems and public opposition that might have occurred had the entire plan been implemented at once.

6. Participation, communication and information

A redevelopment plan for an area of Tübingen faced opposition from the business community, government authorities, and members of the public. However, the redevelopment department was based in the community and was able to establish positive relationships with residents, which eventually helped overcome opposition to the project.

7. Innovative and early efforts to secure resources

In 1992, Bilbao set up a public capital company, which included the central government, the Basque government, and several private entities. The company acts as a development corporation and generates capital by planning and developing land granted by shareholders then selling building sites to private developers.

Source: TRANSPLUS (2002)

4.2 Combinations of Policies

If there is any one consensus within the research on land use-transport planning, it is that combinations of complementary policies are critical in achieving intended outcomes. One

reason is that single measures usually affect only certain localities or segments of the population. Complementary policies can also prevent or counteract negative side effects caused by a single policy. A third reason to coordinate policies is to aid in implementation. Some of the most effective measures—pricing schemes, for example—are politically unpopular, but become more acceptable when packaged with more popular ideas, such as public transit improvements. Indeed, Pucher (1998) suggests that the success of German land use and transport policies to reduce car travel hinges on the comprehensiveness of policy programs. The most successful programs are those which include both measures to support transit and non-motorized travel (“carrot”) as well as measures to make driving less attractive (“stick”). While “stick” measures are more effective in actually reducing car use, “carrot” measures increase public acceptance.

4.2.1 Optimal Policy Packages

Combinations of policies are good, but which combinations are best? Economics research often defines optimal policy combinations as those which provide the greatest benefits to all stakeholders (Jeon & Amekudzi, 2005). Other studies define the best policy packages as those which meet a specified set of criteria, an approach that has been used in modeling studies to test the effects of various policy combinations. In one study, May et al. (2005) applied optimization procedures to land use-transport models to find policy packages that best met criteria for VMT and fuel consumption. The resulting optimal solutions, which were tested under a variety of financial and regulatory constraints, generally included public transit service improvements, lower fares, and congestion fees. In an unusually comprehensive analysis, the EU’s SPARTACUS project used models of Bilbao, Naples, and Helsinki to estimate the impacts of various combinations of land use-transport policies on given social, environmental, and economic criteria. The study confirmed that combinations of policies can produce benefits that are more than the sum of their parts. For example, while pricing policies are the most effective in reducing VMT, they tend to leave rural areas without crucial services, so use of other regulatory policies can mitigate this effect. (LT et al, 1998).

Few studies attempt to draw general conclusions about potential policy combinations using methods other than context-specific case studies and simulations. In a notable exception, Vieira et al. (2007) categorize policy measures and suggest how cities can select combinations in order to exploit the synergies between them.

4.3 Finance Tools for Implementation

A large body of research focuses on tools designed to overcome financial barriers to implementation. A full discussion of transport and real estate finance is outside the scope of this paper, but two finance tools are particularly relevant. The first is value-capture, in which governments try to “capture” the increase in property values produced by transport investments in order to keep economic benefits in the public realm, rather than allowing benefits to transfer to landowners. Value-capture strategies, which may be implemented in the form of taxes or development fees, make transit investments more politically viable and attractive to the public. (See Martinez and Viegas (2007) for a review of various policy instruments associated with value-capture strategies.) Another popular strategy is the public-private partnership, in which investments are jointly financed by public and private means. Numerous studies have

investigated the various possible arrangements, risks and benefits involved, and conditions for success (Gaffron et al, 2002; Bovaird, 2004; Koppenjan, 2005; Zhang, 2005; Phang, 2007).

4.4 Regional Planning and Institutional Structure

This review has highlighted the importance of regional planning framework in enacting successful land use-transport policies. However, there is no consensus on the ideal structure of metropolitan government and there are several valid arguments in favor of more decentralized, autonomous local governance. The literature on relative benefits of regionalism versus localism is vast and mainly centered around issues of economic efficiency, regional competitiveness, and ability to enact sustainable policies (see, for example, Lefevre (1998), Salet (2003), Brenner (2002), and Wheeler (2000)).

Many case studies provide examples of how (the lack of) regional governance structure affects land use and transport planning. In one attempt at meta-analysis, Sager (2006) assessed the role of organizational framework in determining the level of regional coordination in metropolitan planning decisions. Based on 17 case studies of regional planning decisions in Western Europe, the analysis examined the impact of various institutional characteristics on three variables: the degree of sectoral and spatial coordination observed, the degree to which the policies selected were optimal (i.e. satisfied all stakeholders), and whether or not the selected policies were implemented. The study suggests that, in general, a high degree of political centralization within the region is necessary for the implementation of well-coordinated policies. Coordination and implementation are also more likely in settings where technical expertise is separated from political influence.

4.4.1 Policy Integration

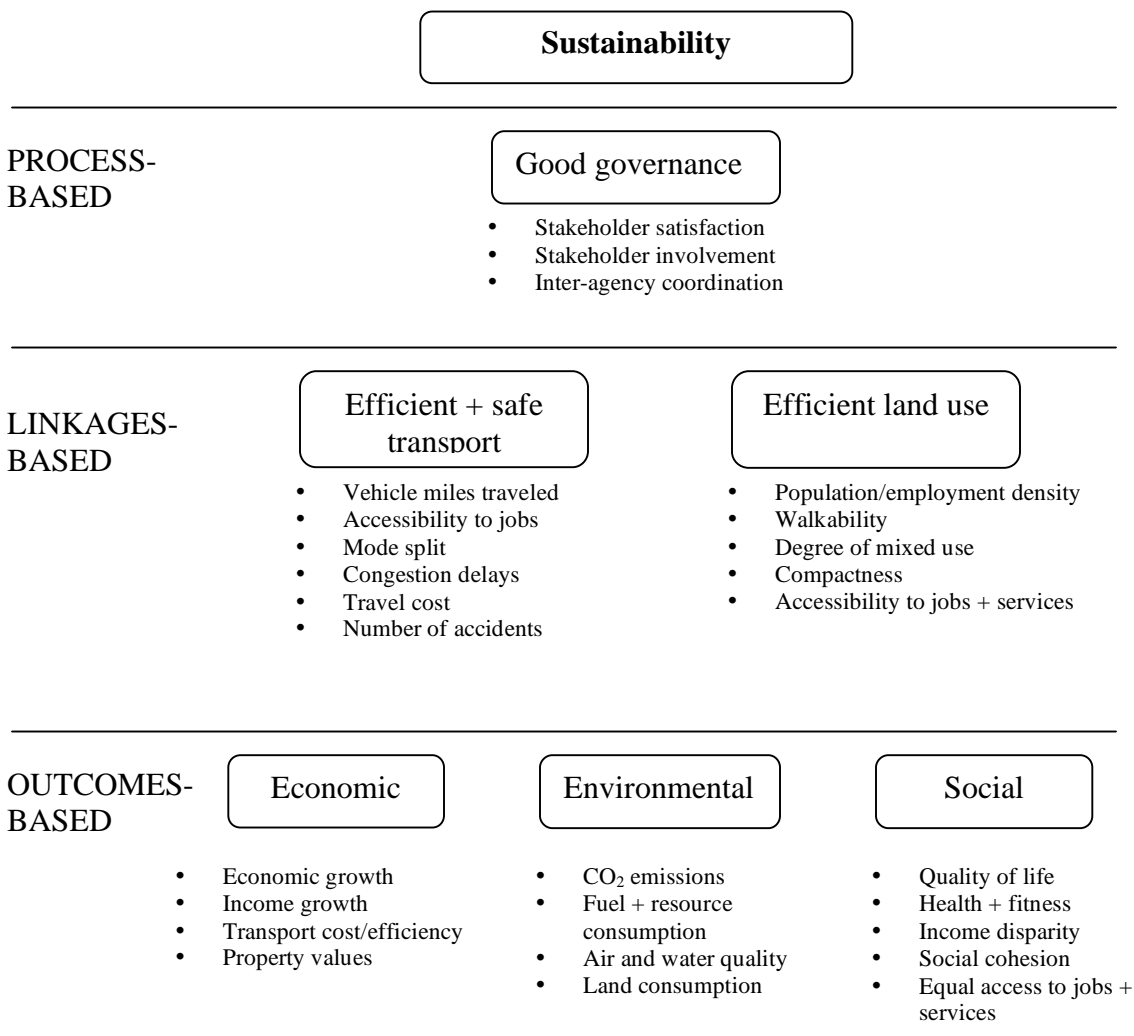
In Europe, there has been an effort to move beyond mere *cooperation* or *coordination* of land use and transport to *policy integration*. Stead et al. (2004) distinguish integration from coordination or cooperation: “whilst coordination aims at adjusting sectoral policies in order to make them mutually enforcing and consistent, policy integration results in one joint policy for the sectors involved” (Stead et al, 2004). As this movement toward integration has grown, so has the research. Geerlings and Stead (2003) offer a useful overview of the issue, while Stead et al. (2004) and May et al. (2006) examine potential barriers to integration. Research on the success of approaches to policy integration is still limited; this may be the subject of future research as more cities specifically aim for integration.

5 Indicators and Evaluation Programs: How is Success Determined?

Clearly, the research reviewed here relies on some definition of what constitutes success, yet there is no standard framework for how to define and measure success in land use planning. For instance, many research studies are concerned with travel behavior, while many planning initiatives emphasize broader economic and social impact; however there is a general consensus that frameworks must be based on the concept of sustainability. Of course, evaluation criteria depend on the specific objectives of each situation. Much has been written on the problem of formulating and selecting indicators for various purposes; a brief overview is presented here (see also Gudmundsson (2001), Jeon and Amekudzi (2005) and Litman (2007)).

In planning and research settings, most approaches to evaluation stem from a definition of sustainability. Goals and objectives—which are also based on the concept of sustainability—are used to inform the selection of indicators, reflecting the particular project’s needs and priorities. Indicators can be designed to capture various successive levels of impacts: they can be (1) *process-based* (i.e. those which capture aspects of the planning process), (2) *linkages-based* (i.e. those which measure the intermediate impacts which, through causal relationships, lead to the desired vision), or (3) *outcomes-based* (i.e. those which measure outcomes which are the ultimate goal) (Jeon & Amekudzi, 2005). For example, a measure of congestion delay is useful when evaluating road projects, yet the ultimate benefits to society are reflected not in terms of congestion relief, but in terms of economic growth. Indicators can also be grouped by whether they capture economic, social, or environmental impacts. Figure 3 presents examples of transport-land use indicators within a framework organized by sustainability principles at relevant levels of influence.

Figure 3. Potential indicators to measure sustainability of land use-transport planning



5.1 The Application of Indicators in Evaluation Programs

The evaluation and monitoring programs used by land use-transport planning initiatives vary widely in scope. Jeon and Amekudzi (2005) reviewed evaluation frameworks employed by 16 “sustainable transport” planning projects and concluded that agencies surveyed generally used a comprehensive set of indicators, although they tended to emphasize transport operation and environmental impact more than economic and social impacts. For example, the EU’s PROSPECTS initiative employs social metrics like “accessibility for those without a car” and “income inequality.” Yet the UK’s Department of Sustainable Development in 2003 used no economic or social indicators, even though “social progress” and “high and stable levels of economic growth and employment” were stated objectives (Jeon & Amekudzi, 2005). Some planning initiatives which are more land use-oriented, such as those in Vancouver, Canada, have adopted targets for urban intensification, which include measures for population and population share, residences and residence share, and employment and employment share for the urban area versus outlying areas (Urban Strategies Strategies, Inc., 2005). Other programs are more comprehensive, like the UK’s Civilising Cities initiative, and use a set of indicators to measure quality of life (Jones et al, 2003). In the U.S., it appears that most cities are only beginning to develop comprehensive monitoring programs (Porter et al, 2005). Similarly, in Europe it is still too early to observe the results of many monitoring programs (Martens & Eijkelenbergh, 2000).

5.2 Indicators Specific to Land Use-Transport Planning

Some indicators apply more specifically to land use-transportation planning, particularly those which capture the interactions between land use and transportation. In terms of travel, the most widely accepted single indicator for sustainability is vehicle miles traveled (VMT), which has the advantage of accounting for trip frequency, trip length, and mode choice, as well as being correlated with fuel consumption and greenhouse gas emissions (Wegener & Furst, 1999). In terms of land use, the literature commonly uses measures of density, which accounts for both land consumption and potential for transit use. The concept of accessibility—or the ability with which people can reach employment, services, and other activities—has received much attention and some authors have developed useful metrics (Krizek, 2003; Geurs & Wee, 2004). More recent research attempts to develop quantifiable measures of land use patterns, like compactness and descriptions of neighborhood type, which can more directly aid in evaluating policy effectiveness (Burton, 2002; Song & Knaap, 2007). Other research currently focuses on developing a practical measurement for quality of life (Steg & Gifford, 2004).

6 Conclusions

Not surprisingly, the research shows that the potential and actual effectiveness of land use-transport policies is mixed and highly dependent upon outside factors. Some issues are well understood, while research in other areas is just beginning. Based on existing research, the following observations may be made.

- The interactions between development patterns and transportation are well-studied, although not entirely conclusive. Density is the strongest land use factor in determining travel behavior, while transportation investments influence development through accessibility.

- The relationship between regional urban form and travel patterns is complex and it is unclear how local conditions influence the interaction. Two questions surrounding urban form—the sustainability of the compact city and the benefits of monocentrism versus polycentrism—continue to be debated, with few clear answers.
- The success of land use policy interventions is highly variable and depends heavily on institutional structure, particularly the degree of coordination between governments and sectors. Strong regional governance is a key factor in the success of the land use interventions which most significantly affect travel behavior.
- Transport system interventions may support urban revitalization, but only under certain conditions. Specifically, economic conditions must be favorable and economic and land use policies should support development.
- Combinations of complementary policies are essential for achieving sustainability goals; the research is beginning to identify methods to determine which combinations are most effective.

6.1 Directions for Future Research

As demonstrated in previous sections, there are still gaps in the knowledge regarding the effectiveness of various policy instruments. In particular, many policies are too recent to produce observable outcomes. This is especially true with land use policies, where the slow rate of land use change means that effects are not seen for several decades. Research is also sparse with regard to some newer transportation interventions, like congestion pricing, where few real-world examples are available. Future research will be able to capture the impacts of these innovations as they develop.

This review has identified several other potential directions for future research. Many of these questions were identified by the EU's PLUME project yet still remain unanswered (Clifford et al, 2005).

- How will new modes change infrastructure needs and influence development patterns? What policies are most likely to promote the positive aspects of those modes?
- Empirical studies are needed on the economic and land use impacts of car sharing programs, bike sharing programs, and investment in bicycle and pedestrian infrastructure.
- How does the provision of pedestrian and bike infrastructure affect the demand for travel of those modes?
- Under what conditions are various strategies and combinations of policies most effective? The interdependencies between characteristics of the urban system and the applicability of land use-transport strategies are still not fully understood.

- In what cases are transportation projects an effective tool for urban revitalization? There is a need for more examples demonstrating the impacts of projects aimed specifically at revitalization.
- Must transport policies necessarily be supported by land use policies? Or can transport policies alone result in more sustainable travel patterns? Taken as a whole, the research has shown that efficient land use is not a *sufficient* condition for sustainable travel. The question remains whether efficient land use is still a *necessary* condition for sustainable travel.
- How do local context and outside factors affect the sustainability of different urban forms? There is still not enough research on the sustainability of various regional development patterns to settle the debate over ideal urban form. In particular, it is unclear at what point a growing city should transition from a monocentric form to a polycentric one (Martens & Eijkelenbergh, 2000).
- What is the tradeoff between increasing density and increasing congestion and what does this mean for sustainability? (Porter et al, 2005)
- What factors make traveling by various modes enjoyable and how important are these in travel behavior?
- How does access to information influence long-term lifestyle choices, especially where to live and work? What about short-term choices? How can information systems promote more sustainable lifestyles?
- There is a need for clearer, more consistent definitions, descriptions, and metrics of land use patterns in order to evaluate effectiveness of policies. Despite the extensive amount of research on indicators, measurements for concepts like urban compactness and walkability are still imperfect.

In summary, it appears that the opportunities for future research on land use-transport policy are numerous, especially as newer planning strategies and transport modes take shape.

Bibliography

- ADONIS. (1998). Analysis and development of new insight into substitution of short car trips by cycling and walking: how to substitute short car trips by cycling and walking (ADONIS). *Transport Research Fourth Framework Programme*. Luxembourg: European Community.
- Alonso, W. (1964). *Location and land use*. Cambridge, MA: Harvard University Press.
- Badoe, D.A., Miller, E.J. (2000). Transportation-land-use interaction: empirical findings in North America, and their implications for modeling. *Transportation Research Part D*, Vol. 5, No. 4, pp. 235-263.
- Bagley, M.N., Mokhtarian, P.L. (2002). The impact of residential neighborhood type on travel behavior: a structural equations modeling approach. *The Annals of Regional Science*, Vol. 36, No. 2, pp. 279-297.
- Bajic, V. (1983). The effects of a new subway line on housing prices in metropolitan Toronto. *Urban Studies*, Vol. 20, No. 2, pp. 147-158.
- Banister, D., Berechman, J. (2000). *Transport Investment and Economic Development*. London: UCL Press.
- Banister, D., Berechman, Y. (2001). Transport investment and the promotion of economic growth. *Journal of Transport Geography*, Vol. 9, No. 3, pp. 209-218.
- Barra, T.d.l. (1989). *Integrated Land Use and Transport Modelling*. Cambridge: Cambridge University Press.
- Bengston, D.N., Fletcher, J.O., Nelson, K.C. (2004). Public policies for managing urban growth and protecting open space: policy instruments and lessons learned in the United States. *Landscape and Urban Planning*, Vol. 69, No. 2-3, pp. 271-286.
- Bhatta, S.D., Drennan, M.P. (2003). The economic benefits of public investment in transportation. *Journal of Planning Education and Research*, Vol. 22, No. 3, pp. 288-296.
- Boarnet, M., Crane, R. (2001). *Travel by design: the influence of urban form on travel*. Oxford: Oxford University Press.
- Boarnet, M.G. (1997). Highways and economic productivity: interpreting recent evidence. *Journal of Planning Literature*, Vol. 11, No. 4, pp. 476-486.
- Boarnet, M.G. (1998). Spillovers and the locational effects of public infrastructure. *Journal of Regional Science*, Vol. 38, No. 3, pp. 381-401.
- Boarnet, M.G., Chalermpong, S.T. (2002). New highways, induced travel, and urban growth patterns: a "before and after" test: University of California Transportation Center; The Environmental Protection Agency.
- Bovaird, T. (2004). Public-private partnerships: from contested concepts to prevalent practice. *International Review of Administrative Sciences*, Vol. 70, No. 2, pp. 199-215.
- Bowes, D.R., Ihlanfeldt, K.R. (2001). Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics*, Vol. 50, No. 1, pp. 1-25.
- Brenner, N. (2002). Decoding the newest "metropolitan regionalism" in the USA: a critical overview. *Cities*, Vol. 19, No. 1, pp. 3-21.
- Burton, E. (2002). Measuring urban compactness in UK towns and cities. *Environment and Planning B*, Vol. 29, No. 2, pp. 219-250.
- CABERNET. (2004). State of the Art Country Profiles, *Concerted Action on Brownfield and Economic Regeneration Network (CABERNET)* Retrieved December 2007, from <http://www.cabernet.org.uk/index.asp?c = 1158>.
- Camagni, R., Gibelli, M.C., Rigamonti, P. (2000). *Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion*. 40th Congress of the European Regional Science Association, Barcelona. August 29, 2000.

- Cambridge Systematics. (1998). Economic Impact Analysis of Transit Investments: Guidebook for Practitioners. *Transit Cooperative Research Program*. Washington, DC: Transportation Research Board.
- Cervero, R. (1994). Rail transit and joint development: Land market impacts in Washington, D.C. and Atlanta. *Journal of the American Planning Association*, Vol. 60, No. 1, pp. 83-95.
- Cervero, R. (1998). *The Transit Metropolis: A Global Inquiry*. Washington, DC: Island Press.
- Cervero, R. (2003). The built environment and travel: evidence from the United States. *European Journal of Transport and Infrastructure Research*, Vol. 3, No. 2, pp. 119-137.
- Cervero, R. (2003). Road expansion, urban growth, and induced travel: a path analysis. *Journal of the American Planning Association*, Vol. 69, No. 2, pp. 145-163.
- Cervero, R. (2007). Transit-oriented development's ridership bonus: a produce of self-selection and public policies. *Environment and Planning A*, Vol. 39, No. 9, pp. 2068-2085.
- Cervero, R., Duncan, M. (2003). Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area. *American Journal of Public Health*, Vol. 93, No. 9, pp. 1478-1483.
- Cervero, R., Kockelman, K. (1997). Travel demand and the 3Ds: Density, Diversity, and Design. *Transportation Research Part D*, Vol. 2, No. 3, pp. 199-219.
- Cervero, R., Landis, J. (1997). Twenty years of the Bay Area Rapid Transit system: land use and development impacts. *Transportation Research A*, Vol. 31A, No. 4, pp. 309-333.
- Cervero, R., Murphy, S., Ferrell, C. (2002). Transit-oriented development and joint development in the United States: a literature review. *TCRP Research Results Digest*, No. 52.
- Cervero, R., Murphy, S., Ferrell, C., Goguts, N., Tsai, Y.-H., Arrington, G.B., Boroski, J., Smith-Heimer, J., Golem, R., Peninger, P., Nakajima, E., Chui, E., Dunphy, R., Myers, M., Witenstein, N. (2004). Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects. *Transit Cooperative Research Program*. Washington, DC: Transportation Research Board.
- Cervero, R., Tsai, Y. (2004). City CarShare in San Francisco, California: second-year travel demand and car ownership impacts. *Transportation Research Record*, Vol. 1887, pp. 117-127.
- Cervero, R., Wu, K.-L. (1998). Sub-centering and commuting: evidence from the San Francisco Bay Area, 1980-90. *Urban Studies*, Vol. 35, No. 7, pp. 1059-1076.
- Clark, W.A.V., Kuijpers-Linde, M. (1994). Commuting in restructuring urban regions. *Urban Studies*, Vol. 31, No. 3, pp. 465-483.
- Clifford, S., Blackledge, D., May, T., Jopson, A., Sessa, C., Haon, S. (2005). Planning and Urban Mobility in Europe (PLUME): Final Report: European Commission.
- Crane, R. (1996). On form versus function: will the New Urbanism reduce traffic, or increase it? *Journal of Planning Education and Research*, Vol. 15, No. 2, pp. 117-126.
- Crane, R., Crepeau, R. (1998). Does neighborhood design influence travel?: a behavioral analysis of travel diary and GIS data. *Transportation Research Part D*, Vol. 3, No. 4, pp. 225-238.
- Damm, D., Lerman, S.R., Lerner-Lam, E., Young, J. (1980). Response of urban real estate values in anticipation of the Washington Metro. *Journal of Transport Economic and Policy*, Vol. 14, pp. 315-336.
- Debrezion, G., Pels, E., Rietveld, P. (2007). The impact of railway stations on residential and commercial property value: a meta-analysis. *The Journal of Real Estate Finance and Economics*, Vol. 35, No. 2, pp. 161-180.
- DeMaio, P., Gifford, J. (2004). Will smart bikes succeed as public transportation in the United States? *Journal of Public Transportation*, Vol. 7, No. 2, pp. 1-16.
- Deneef, H., Schroder, S. (2002). Car Restricted Oriented Development: Significant Practice in Europe. *Transport Planning Land-Use and Sustainability (TRANSPLUS)*: European Commission.
- Deweese, D. (1976). The effect of a subway on residential property values in Toronto. *Journal of Urban Economics*, Vol. 3, No. 4, pp. 357-369.
- DiDonato, M., Herbert, S., Vachhani, D. (2002). City-bike maintenance and availability: Worcester Polytechnic Institute. Vol. B.S. thesis.

- Dieleman, F.M., Dijst, M.J., Spit, T. (1999). Planning the compact city: the Randstad Holland experience. *European Planning Studies*, Vol. 7, No. 5, pp. 605-621.
- Downs, A. (2003). Why Florida's concurrency principles (for controlling new development by regulating road construction) do not--and cannot--work effectively. *Transportation Quarterly*, Vol. 57, No. 1, pp. 13-18.
- Enoch, M.P., Taylor, J. (2006). A worldwide review of support mechanisms for car clubs. *Transport Policy*, Vol. 13, No. 5, pp. 434-443.
- Evans, J.E., Pratt, R.H., Stryker, A., Kuzmyak, J.R. (2007). Transit Oriented Development: Traveler Response to Transportation System Changes. *Transit Cooperative Research Program*. Washington, DC: Transportation Research Board.
- Ewing, R., Cervero, R. (2001). Travel and the built environment: a synthesis. *Transportation Research Record*, Vol. 1780, pp. 87-114.
- Filion, P., McSpurren, K. (2007). Smart growth and development reality: the difficult co-ordination of land use and transport. *Urban Studies*, Vol. 44, No. 3, pp. 501-524.
- Fontana, M. (1999). *Car-free areas and pedestrianisation for traffic management: the experience of five Italian towns*. ECMT/OECH Workshop on Managing Car Use for Sustainable Urban Travel, Dublin. December 1999.
- Gaffron, P. (2002). Synthesis Report: Implementation. *Planning and Urban Mobility in Europe (PLUME)*: European Commission.
- Gaffron, P., Streich, S., Djekrif, R., Racine, C., Schneider, J. (2002). Public Private Partnerships around Urban Rail Transit: European Centre for Transportation and Logistics, Technische Universitat Hamburg-Harburg.
- Ganser, R., Williams, K. (2007). Brownfield development: are we using the right targets? Evidence from England and Germany. *European Planning Studies*, Vol. 15, No. 5, pp. 603-622.
- Gatzlaff, D., Smith, M. (1993). The impact of the Miami Metrorail on the value of residences near station locations. *Land Economics*, Vol. 69, No. 1, pp. 54-66.
- Geerlings, H., Stead, D. (2003). The integration of land use planning, transport and environment in European policy and research. *Transport Policy*, Vol. 10, No. 3, pp. 187-196.
- Geurs, K.T., Wee, B.v. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, Vol. 12, No. 2, pp. 127-140.
- Giuliano, G. (2004). Land Use Impacts of Transportation Investments: Highway and Transit. *The Geography of Urban Transportation* (Hanson, S. & Giuliano, G., Eds.). New York: The Guilford Press, pp. 237-273.
- Gordon, P., Richardson, H. (1997). Are compact cities a desirable planning goal? *Journal of the American Planning Association*, Vol. 63, No. 1, pp. 95-105.
- Gout, P., Heilemann, A. (2002). Public Transport Oriented Development: Significant Practice in Europe. *Transport Planning Land-Use and Sustainability (TRANSPLUS)*: European Commission.
- Grass, R.G. (1992). The estimation of residential property values around transit station sites in Washington, D.C. *Journal of Economics and Finance*, Vol. 16, pp. 139-146.
- Gudmundsson, H. (2001). Indicators and performance measures for transportation, environment and sustainability in North America. Roskilde, Denmark: National Environmental Research Institute.
- Handy, S. (2005). Smart growth and the transportation-land use connection: what does the research tell us? *International Regional Science Review*, Vol. 28, No. 2, pp. 146-167.
- Handy, S., Cao, X., Buehler, T.J., Mokhtarian, P. (2005). *The link between the built environment and travel behavior: correlation or causality?* 84th Annual Meeting of the Transportation Research Board, Washington, DC. January 2005.
- Handy, S., Clifton, K.J. (2001). Local shopping as a strategy for reducing automobile travel. *Transportation*, Vol. 28, No. 4, pp. 317-346.
- Hansen, M., Gillen, D., Puvathingal, M. (1998). Freeways expansion and land development: an empirical analysis of transportation corridors. Berkeley: Institute for Transportation Studies, University of California, Berkeley.

- Harder, M., Miller, E. (2000). Effects of transportation infrastructure and location on residential real estate values: application of spatial autoregressive technique. *Transportation Research Record*, Vol. 1722, pp. 1-8.
- Henry, A. (2004). Synthesis Report: Pricing. *Planning and Urban Mobility in Europe (PLUME)*: European Commission.
- Jenks, M. (2000). The Acceptability of Urban Intensification. *Achieving Sustainable Urban Form* (Williams, K., Burton, E. & Jenks, M., Eds.). London: Spon Press.
- Jeon, C.M., Amekudzi, A. (2005). Addressing sustainability in transportation systems: definitions: indicators, and metrics. *Journal of Infrastructure Systems*, Vol. 11, No. 1, pp. 31-50.
- Jones, P., Lucas, K., Whittles, M. (2003). Evaluating and implementing transport measures in a wider policy context: the 'Civilising Cities' initiative. *Transport Policy*, Vol. 10, No. 3, pp. 209-221.
- Jun, M.-J. (2004). The effects of Portland's urban growth boundary on urban development patterns and commuting. *Urban Studies*, Vol. 41, No. 7, pp. 1333-1348.
- Kavage, S.E., Moudon, A.V., Mabry, J.E., Pergakes, N. (2005). Transportation-efficient land use regulations and their application in the Puget Sound Region, Washington. *Transportation Research Record*, Vol. 1902, pp. 44-54.
- Koppenjan, J.F.M. (2005). The formation of public-private partnerships: lessons from nine transport infrastructure projects in the Netherlands. *Public Administration*, Vol. 83, No. 1, pp. 135-157.
- Krizek, K.J. (2003). Operationalizing neighborhood accessibility for land use-travel behavior research and regional modeling. *Journal of Planning Education and Research*, Vol. 22, No. 3, pp. 270-287.
- Krizek, K.J. (2003). Residential relocation and changes in urban travel: does neighborhood scale urban form matter? . *Journal of the American Planning Association*, Vol. 69, No. 3, pp. 265-281.
- Krizek, K.J. (2004). Estimating the economic benefits of bicycling and bicycle facilities: an interpretive review and proposed methods. *TRB 2004 Annual Meeting CD-ROM*.
- Kuzmyak, J.R., Pratt, R.H., Douglas, G.B. (2003). Traveler Response to Transportation System Changes: Land Use and Site Design. *Transit Cooperative Research Program: Transportation Research Board*.
- Lamrani, Y. (2004). Synthesis Report: Travel Demand Management. *Planning and Urban Mobility in Europe (PLUME)*: European Commission.
- Lane, C. (2005). PhillyCarShare: first-year social and mobility impacts of carsharing in Philadelphia, Pennsylvania. *Transportation Research Record*, Vol. 1927, pp. 158-166.
- Lautso, K. (2004). *The PROPOLIS approach to urban sustainability and the application of the approach in seven European cities*. Transportation Research Board 2005 Annual Meeting, Washington, DC, Transportation Research Board.
- Lefevre, C. (1998). Metropolitan government and governance in Western countries: a critical review. *International Journal of Urban and Regional Research*, Vol. 22, No. 1, pp. 9-25.
- Levine, J., Inam, A., Torng, G.-W. (2005). A choice-based rationale for land use and transportation alternatives. *Journal of Planning Education and Research*, Vol. 24, No. 3, pp. 317-330.
- Levinson, H., Wynne, F. (1963). Effects of density on urban transportation requirements. *Highway Research Record*, Vol. 2, pp. 38-64.
- Levinson, H., Zimmerman, S., Clinger, J., Rutherford, S., Smith, R.L., Cracknell, J., Soberman, R. (2003). Bus Rapid Transit. Volume 1: Case Studies in Bus Rapid Transit. *Transit Cooperative Research Program*. Washington, DC: Transportation Research Board.
- Litman, T. (2000). Evaluating Carsharing Benefits. *Transportation Research Record*, Vol. 1702, pp. 31-35.
- Litman, T. (2003). Economic Value of Walkability. *Transportation Research Board*, Vol. 1828, pp. 3-11.
- Litman, T. (2007). *Developing indicators for comprehensive and sustainable transport planning*. Transportation Research Board Annual Meeting, Washington, DC, Transportation Research Board. January 2007.

- LT, ME&P, MECSA, IRPUD, TRT. (1998). System for Planning and Research in Towns and Cities for Urban Sustainability (SPARTACUS): Final Report. *Environmental and Climate Research Programme*. Helsinki: LT Consultants.
- Lund, H. (2003). Local access, pedestrian travel, and neighboring behaviors. *Journal of the American Planning Association*, Vol. 69, No. 4, pp. 414-429.
- Lund, H.M., Cervero, R., Willson, R.W. (2004). Travel Characteristics of Transit-Oriented Development in California. *Statewide Planning Studies*: Caltrans.
- Maat, K., van Wee, B., Stead, D. (2005). Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories. *Environment and Planning B*, Vol. 32, No. 1, pp. 33-46.
- Marshall, S. (2004). Synthesis Report: Infrastructure Provision. *Planning and Urban Mobility in Europe (PLUME)*: European Commission.
- Marshall, S., Banister, D. (2000). Travel reduction strategies: Intentions and outcomes. *Transportation Research Part A*, Vol. 34, No. 5, pp. 321-338.
- Martens, M., Eijkelenbergh, P., (Eds.). (2000). *Assessment of integrated land use and transport planning strategies*. Transport Planning Land-Use and Sustainability (TRANSPLUS): European Commission.
- Martinez, L.M., Viegas, J.M. (2007). Metropolitan transportation systems financing using the value capture concept: Unpublished paper for Lisbon Technical University.
- Matsuura, M. Case Studies (Bicycle sharing research project), Retrieved December 2007, from <http://www.mmatsuura.com/e/research/bicycle/cases.html>.
- May, A.D., Kelly, C., Shepherd, S. (2006). The principles of integration in urban transport strategies. *Transport Policy*, Vol. 13, No. 4, pp. 319-327.
- May, A.D., Shepherd, S.P., Emberger, G., Ash, A., Zhang, X., Paulley, N. (2005). Optimal land use-transport strategies: methodology and application to European cities. *Transportation Research Record*, Vol. 1924, pp. 129-138.
- McCarthy, L. (2002). The brownfield dual land-use policy challenge: reducing barriers to private redevelopment while connecting reuse to broader community goals. *Land Use Policy*, Vol. 19, No. 4, pp. 287-296.
- Millard-Ball, A., Murray, G., Schure, J.t., Fox, C., Burkhardt, J. (2005). Car-Sharing: Where and How It Succeeds. *Transit Cooperative Research Program*. Washington, DC: Transportation Research Board.
- Mills, E.S. (1972). *Studies in the structure of the urban economy*. Baltimore: Johns Hopkins University Press.
- Muth, R. (1969). *Cities and housing*. Chicago: University of Chicago Press.
- Naess, P. (2006). *Urban structure matters: residential location, car dependence and travel behaviour*. Oxfordshire: Routledge.
- Nelson, A.C. (1999). Comparing states with and without growth management: analysis based on indicators with policy implications. *Land Use Policy*, Vol. 16, No. 2, pp. 121-127.
- Newman, P.W.G., Kenworthy, J.R. (1991). Transport and urban form in thirty-two of the world's principal cities. *Transport Reviews*, Vol. 11, No. 3, pp. 249-272.
- Noland, R.B., Ishaque, M.M. (2006). Smart bicycles in an urban area: evaluation of a pilot scheme in London. *Journal of Public Transportation*, Vol. 9, No. 5, pp. 71-95.
- Parsons Brinckerhoff Quade & Douglas, Inc. (1996) Transit and Urban Form, *Transit Cooperative Research Program*: Transportation Research Board.
- Payne-Maxie Consultants. (1980). The land use and development impacts of beltways. Report DOT-p-30-30-38. Washington, DC: U.S. Department of Transportation.
- Phang, S.-Y. (2007). Urban rail transit PPPs: Survey and risk assessment of recent strategies. *Transport Policy*, Vol. 14, No. 3, pp. 214-231.

- Pickrell, D. (1999). *Transportation and Land Use. Essays in transportation economics and policy* (Gomez-Ibanez, J., Tye, W.B. & Winston, C., Eds.). Washington, D.C.: Brookings Institution Press.
- Porter, C.D., Siethoff, B.t., Smith, V. (2005). Impacts of comprehensive planning and smart growth initiatives on transportation: Case studies of five regions. *Transportation Research Record*, Vol. 1902, pp. 91-98.
- Prud'homme, R., Bocarejo, J.P. (2005). The London congestion charge: a tentative economic appraisal. *Transport Policy*, Vol. 12, No. 3, pp. 279-287.
- Pucher, J. (1998). Urban transport in Germany: providing feasible alternatives to the car. *Transport Reviews*, Vol. 18, No. 4, pp. 285-310.
- Pushkarev, B.S., Zupan, J.M. (1977). *Public Transportation and Land Use Policy*. Bloomington: Indiana University Press.
- Quddus, M., Carmel, A., Bell, M.G.H. (2005). Working Paper 12: The congestion charge's impact on retail - The London experience. London: Greater London Authority.
- Redmond, L.P., Mokhtarian, P. (2001). The positive utility of the commute: modeling ideal commute time and relative desired commute amount. *Transportation*, Vol. 28, pp. 179-205.
- Renne, J.L. (2005). Transit-oriented development: measuring benefits, analyzing trends, and evaluating policy. *Department of Urban Planning and Policy Development*: Rutgers University.
- Rickaby, P.A. (1987). Six settlement patterns compared. *Environment and Planning B*, Vol. 14, pp. 193-223.
- RICS. (2002). *Land value and public transport: Stage 1--summary of findings*. UK: Office of the Deputy Prime Minister.
- Rodriguez, D.A., Targa, F. (2004). Value of accessibility to Bogota's bus rapid transit system. *Transport Reviews*, Vol. 24, No. 5, pp. 587-610.
- Rodriguez, D.A., Targa, F., Aytur, S.A. (2006). Transport implications of urban containment policies: a study of the largest twenty-five US metropolitan areas. *Urban Studies*, Vol. 43, No. 10, pp. 1879-1897.
- Sager, F. (2006). Policy coordination in the European metropolis: a meta-analysis. *West European Politics*, Vol. 29, No. 3, pp. 433-460.
- Salet, W., Thornley, A., Kreukels, A., (Eds.). (2003). *Metropolitan governance and spatial planning: comparative case studies of European city-regions*. London; New York: Spon Press.
- Sanchez, T.W. (2004). Land use and growth impacts from highway capacity increases. *Journal of Urban Planning and Development*, Vol. 130, No. 2, pp. 75-82.
- Santos, G. (2005). Urban congestion charging: a comparison between London and Singapore. *Transport Reviews*, Vol. 25, No. 5, pp. 511-534.
- Schafer, A., Victor, D.G. (2000). The future mobility of the world population. *Transportation Research A*, Vol. 34, pp. 171-205.
- Scheurer, J. (1999). Car-free housing in European cities, Retrieved November, 2007.
- Schwanen, T., Dieleman, F.M., Dijst, M. (2003). Car use in Netherlands daily urban systems: does polycentrism result in lower commute times? *Urban Geography*, Vol. 24, No. 5, pp. 340-360.
- Schwanen, T., Dijst, M., Dieleman, F.M. (2004). Policies for urban form and their impact on travel: the Netherlands experience. *Urban Studies*, Vol. 41, No. 3, pp. 579-603.
- Shaheen, S.A., Cohen, A.P. (2007). Growth in worldwide carsharing: an international comparison. *Transportation Research Record*, Vol. 1992, pp. 81-89.
- Shen, Q., Zhang, F. (2007). Land-use changes in a pro-smart-growth state: Maryland, USA. *Environment and Planning A*, Vol. 39, No. 6, pp. 1457-1477.
- Smith, H., Raemaekers, J. (1998). Land use pattern and transport in Curitiba. *Land Use Policy*, Vol. 15, No. 3, pp. 233-251.
- Song, Y. (2005). Smart growth and urban development pattern: a comparative study. *International Regional Science Review*, Vol. 28, No. 2, pp. 239-265.

- Song, Y., Knaap, G.-J. (2007). Quantitative classification of neighbourhoods: the neighbourhoods of new single-family homes in the Portland metropolitan area. *Journal of Urban Design*, Vol. 12, No. 1, pp. 1-24.
- Sousa, C.A.D. (2002). Measuring the public costs and benefits of brownfields versus greenfield development in the Greater Toronto area. *Environment and Planning B*, Vol. 29, No. 2, pp. 251-280.
- Spiekermann, K., Wegener, M. (2004). Evaluating urban sustainability using land-use transport interaction models. *European Journal of Transport and Infrastructure Research*, Vol. 4, No. 3, pp. 251-272.
- Stead, D. (2001). Relationships between land use, socioeconomic factors, and travel patterns in Britain. *Environment and Planning B*, Vol. 28, No. 4, pp. 499-528.
- Stead, D., Geerlings, H., Meijers, E., (Eds.). (2004). *Policy integration in practice: The integration of land use planning, transport and environmental policy-making in Denmark, England, and Germany*. Delft: Delft University Press.
- Stead, D., Marshall, S. (2001). The relationships between urban form and travel patterns: An international review and evaluation. *European Journal of Transport and Infrastructure Research*, Vol. 1, No. 2, pp. 113-141.
- Steg, L., Gifford, R. (2004). Sustainable transportation and quality of life. *Journal of Transport Geography*, Vol. 13, No. 1, pp. 59-69.
- Ten Siethoff, B., Kockelman, K.M. (2002). Property values and highway expansions: timing, size, location and use effects. *Transportation Research Record*, Vol. 1812, pp. 191-200.
- Topp, H., Pharoah, T. (1994). Car-free city centres. *Transportation*, Vol. 21, No. 3, pp. 231-247.
- TRANSPLUS. (2002). Assessment of Barriers and Solutions. *Transport Planning Land-Use and Sustainability (TRANSPLUS)*: European Commission.
- Transport for London. (2007). Central London Congestion Charging--Impacts Monitoring: Fifth Annual Report: Transport for London.
- Urban Strategies. (2005). Intensification Target for the Greater Golden Horseshoe: Ontario Growth Secretariat, Ministry of Public Infrastructure Renewal.
- van Wee, B. (2002). Land use and transport: research and policy challenges. *Journal of Transport Geography*, Vol. 10, No. 4, pp. 259-271.
- Vance, C., Hedel, R. (2007). The impact of urban form on automobile travel: disentangling causation from correlation. *Transportation*, Vol. 34, No. 5, pp. 575-588.
- Vieira, J., Moura, F., Viegas, J.M. (2007). Transport policy and environmental impacts: The importance of multi-instrumentality in policy integration. *Transport Policy*, Vol. 14, No. 5, pp. 421-432.
- Voith, R. (1993). Changing capitalization of CBD-oriented transportation systems: evidence from Philadelphia, 1970-1988. *Journal of Urban Economics*, Vol. 33, pp. 361-376.
- von Thunen, J. (1826). *Der Isolierte Staat in Beziehung ant Landwirtschaft and Nationalekonomie*. Hamburg.
- Waddell, P., Franklin, J., Britting, J. (2003). UrbanSim: development, application, and integration with the Wasatch Front regional travel model: Technical Report CUSPA-03-01.
- Webster, F.V., Paulley, N.J., (Eds.). (1990). *Urban Land-Use and Transport Interaction: Policies and Models*. Report of the International Study Group on Land-Use/-Transport Interaction (ISGLUTI). Aldershot: Avebury.
- Wegener, M., Furst, F. (1999). Land-Use Transport Interaction: State of the Art. *Integration of Transport and Land Use Planning (TRANSLAND)*: European Commission.
- Wheeler, S. (2000). Planning for metropolitan sustainability. *Journal of Planning Education and Research*, Vol. 20, No. 2, pp. 133-145.
- Whitehead, T. (2005). Transport charging interventions and economic activity. *Transport Policy*, Vol. 12, No. 5, pp. 451-463.
- Whitehead, T., Simmonds, D., Preston, J. (2006). The effect of urban quality improvements on economic activity. *Journal of Environmental Management*, Vol. 80, No. 1, pp. 1-12.

- Williams, K. (1999). Urban intensification policies in England: problems and contradictions. *Land Use Policy*, Vol. 16, No. 3, pp. 167-178.
- Williams, K. (2000). Does Intensifying Cities Make them More Sustainable? *Achieving Sustainable Urban Form* (Williams, K., Burton, E. & Jenks, M., Eds.). London: Spon Press.
- Zhang, X. (2005). Critical success factors for public-private partnerships in infrastructure development. *Journal of Construction Engineering and Management*, Vol. 131, No. 1, pp. 3-14.
- Zhang, Y., Shing, H.-F. (2006). The London congestion charge and property prices: an evaluation of the impact on property prices inside and outside the zone: London School of Economics.